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16. ABSTRACT

The objective of the project was to investigate the potentialities of reducing the particulate exhausted from diesel-powered passenger cars by the use of available lead trap technology. The particulate exhausted from diesels is one of several currently non-regulated emissions that is of concern, especially if the anticipated growth in diesel cars occurs.

A system including front and rear agglomerator devices, packed with alumina coated steel wool, and an inertial separator, were mounted in place of the usual front resonator and rear muffler. When relatively new, the system was found to be effective on particulates and also reduced exhaust hydrocarbons, odor, smoke, benzo (a) pyrene, and sulfate. Acceleration performance suffered due to increased backpressure from the system. The life of the system is relatively short, less than 5000 km.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
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FOREWORD

This project was conducted for the U.S. Environmental Protection Agency by the Department of Emissions Research, Automotive Research Division of Southwest Research Institute. The EPA Project Officer was Mr. Ralph C. Stahman. Assisting the Project Officer on this project, and hereby acknowledging his assistance, was Mr. John J. McFadden, also of the Ann Arbor, Michigan, EPA Laboratories.

This project was under the overall direction of Mr. Karl J. Springer, Director of the Department of Emissions Research who served as Project Manager. Mr. Orville J. Davis was responsible for the experimental laboratory evaluations. The project began in July 1975 and was authorized by Modification 3 to Contract No. 68-03-2116. It was known within Southwest Research Institute as Project No. 11-4016-002 and constituted Part VIII of a long-range investigation of diesel emissions begun in 1966.

ABSTRACT

The objective of the project described in this report was to investigate the potentialities of reducing the particulate exhausted from diesel-powered passenger cars by the use of available lead trap technology. From a total of 48 particulate trap items, or combinations, involving some 377 screening tests, a system was identified that initially reduced exhaust particulate from a 1975 Mercedes 300D diesel car by two-thirds. This car, uncontrolled, could emit 0.312 g/km or 25.1 kg in 80,450 km (50,000 mi) of operation. The system included front and rear agglomerator devices that mounted where the usual front resonator and rear muffler were located. Each agglomerator was packed with Texaco, Inc. alumina coated steel wool. An inertial separator (Ethyl Corp. tangential anchored vortex or Houston Chemical Co. swirl tube) was mounted at the outlet of the rear agglomerator. The system was, when relatively new, found to be effective not only on particulate but reduced exhaust hydrocarbons, odor, smoke, benzo(a)pyrene, and sulfate. Acceleration performance was reduced due to the substantial increase in backpressure due to the trap system. Proof of principal experiments included 12,068 km (7500 mi) of durability testing on the MVMA test cycle. The agglomerators ceased to function as a trap after about 4843 km (3010 mi), of which 2000 km (1227 mi) was by the MVMA durability test. The test was continued even though the agglomerators appeared to have reached equilibrium. The durability test was continued to establish the potential of agglomeration-separation and to investigate the effect of the particulate removal system on sulfate and other emissions. During the test, the inertial separators continued to remove some particulate and were even found slightly effective with the standard factory system, on the order of 10 percent or less. Complete test details and results are presented.

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I. SUMMARY

A four-part project was performed to investigate the potential of using available lead trap technology to reduce particulate emissions from a 1975 Mercedes 300D, 5 cylinder diesel-powered car. The major findings are summarized as follows:

Road Exhaust Temperature Survey - The three transient driving cycles of interest: the urban or Federal Test Procedure (FTP), the sulfate emissions test (SET), and the highway fuel economy test (FET) were driven on the road and a variety of exhaust temperature profiles obtained. These profiles were then simulated during chassis dynamometer testing by use of multiple blowers turned "on" and "off" as the vehicle speed was varied. In contrast to the Federal Test Procedure for gaseous emissions and fuel economy testing, the underhood temperatures, such as exhaust manifold temperature, etc., were best simulated with the hood down. The standard test procedure involves a single cooling fan with the hood fully opened.

Screening - A wide variety of hardware items were obtained through the courtesy of Houston Chemical Company, Ethyl Corporation, and Texaco, Inc. These companies had extensive experience in trapping lead particulate from gasoline fueled cars but had not tried their devices on diesel particulate. For screening purposes, the 23 minute city driving schedule featured in the FTP was employed during which time particulate was collected on duplicate, preweighed 47 mm fiberglass filters. A 45.7 cm (18 in) diameter by 4.88 m (16 ft) long dilution tunnel, handling a nominal 14.15 m^3/min (500 CFM), allowed dilution of the entire exhaust flow of the car. The definition of the particulate was in terms of the collection system in which the filter temperature was always less than 52°C (125°F). Dilution was sufficient to prevent condensation of water on the filter even though the filter collected sulfate and unburned fuel and oil aerosols along with carbon or soot particulate.

A total of 377 runs were made of some 48 components or combinations of components. In general, the test items could be considered either an agglomerator or a separator, even though there were several integral systems and the combination of separate components into a total system. The screening tests identified the Texaco alumina coated steel wool packed devices to work best on particulate from the Mercedes 300D. Two units were evaluated--one designated A-1F which was fairly small and oval in cross section that replaced the front muffler or resonator. The other, and most effective of any component evaluated, was designated A-IR. It fit into the place where the larger factory rear cylindrical muffler was located. The best separator found was a relatively high pressure drop inertial unit--the Ethyl single tangential anchored vortex (TAV_s). The Houston Chemical Company (HCC) swirl tube separator, also a relatively high pressure drop inertial device, was found to have some promise for separation of once agglomerated particulate.

During the screening test, it was found that the combination of the A-IF, A-IR, and TAV_s was effective in reducing particulate from 0.312 g/km to about 0.11 g/km, or by two-thirds. The SwRI target for this project was a 50 percent reduction. Although this reduction was accompanied by almost eight times increase in exhaust backpressure, this was not considered so excessive as to discontinue the experimentation. Incidentally, at the rate of 0.312 g/km, the car could exhaust 25.1 kg (55.3 lbs) of particulate in 80,450 km (50,000 mi).

Evaluation - This third part of the project investigated the effect of the particulate system on gaseous emissions of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), smoke, odor, noise, acceleration performance, fuel economy, benzo(a)pyrene (BaP), sulfate, non-reactive hydrocarbons, and elemental analysis of the particulate. At the start of the extensive evaluation, the A-IR had 1727 km (1073 mi) and the A-IF had 915 km (569 mi) of operation. The major effects for the replicate FTP, SET, and FET test cycles are listed as follows for the particulate system relative to the standard factory system under comparable test conditions:

HC - about 40 percent less
CO, NO_x - no change
Fuel Consumption - slight increase
Noise - directional, higher exhaust exit noise
Exhaust Pressures - substantially higher at 50 mph, 279 mm Hg (11 in Hg) versus 25 mm Hg (1 in Hg), i.e., 11 times higher
Odor - noticeably less and different odor characteristic
DOAS - lower as per panel ratings
Smoke - lower overall, lower but broader peaks during acceleration
Sulfate - 10 percent of factory system
BaP - about half factory system
Acceleration Rate - up to 20 percent decrease at WOT

The major concerns with the system were the substantial exhaust backpressure; major effect on wide-open throttle performance; and, of course, the life of the agglomerators. The noticeable, and in some cases substantial, effect on hydrocarbons, odor, smoke, sulfate, and BaP required that further investigation be given the particulate removal system.

Durability - Throughout the screening and evaluation tests, the effectiveness of the A-IR unit tended to decrease and it was known that eventually the system would fill and either plug up or equilibrate somehow. The only way to find this was to accumulate a reasonable amount of road operation with intermittent test and evaluation. Fortunately, the system was designed by SwRI to fit well enough under the car for operation over the durability test course (on public roads) normally used for emissions durability testing.

From analysis of the particulate emission rates and backpressure readings, it was estimated that the trap system reached equilibrium after about 2000 km (1227 mi) of durability testing. At that time, the A-IF had accumulated 4041 km (2512 mi) and the A-IR had accumulated 4853 km (3010 mi) of total operation, including screening and evaluation. At that point in the durability test, the Texaco alumina coated steel wool filled units were working presumably as agglomerators and no longer as traps and agglomerators. The durability test was continued to 12,068 km (7500 mi) to investigate the potential of agglomeration-separation and to determine the effect of the particulate removal system on sulfate and gaseous emissions such as HC. No size distribution measurements were taken before and after the A-IR for example; and, therefore, it is presumed that the unit did in fact agglomerate the exhaust particulate. This presumption is borne out by the ability of the separators to function better than originally predicted during screening. During the final evaluation, after 12,068 km (7500 mi) of MVMA testing, it was found that the particulate trap system was still removing sulfate. The efficiency had dropped from 90 percent, at the start, to about 50 percent.

A total of 12,068 km (7500 mi) of durability operation was given the A-IF and A-IR during which time both the TAV_s and swirl separators collected particulate which was subsequently weighed and the bulk density determined. It was found that when the A-IF and A-IR were new and acting as traps (as well as agglomerators), the density of the particulate was 0.066 g/cm^3. After equilibrium was reached and the A-IF and A-IR units were operating presumably as agglomerators, the density dropped to 0.034 g/cm^3, although the volume collection rate was not greatly different. When used with the stock factory exhaust system, the inertial separators collected particulate with a density of about ten times more than that with the A-IF, A-IR-TAV system. The mass collection rate in the separators was about the same as when the agglomerators were new. The volume collection rate was, therefore, much less due to the much higher density of particulate. The particulate was much more dense as if compacted by the separator when used alone with the factory system during the final 4023 km (2500 mi) of the 16,090 km (10,000 mi) durability test.

In conclusion of this summary, the Texaco alumina packed agglomerators were quite efficient when new in trapping and removing particulate. These units were also effective in reducing sulfate, HC, BaP, and odor from the Mercedes 300D. But, the life of the system is relatively short, on the order of 4853 km (3016 mi). Exhaust backpressure on the engine is quite high, and much needs to be done to reduce this detrimental effect while increasing life and retaining other advantages.

The separators worked to a limited, but surprising, extent with the agglomerators and even the factory system. Particulate thus collected had a higher density with the factory system and would be expected to be on the order of 10 percent of the total particulate exhausted. Additional work will be necessary to fully exploit the full potential of both the agglomerators and separators identified and evaluated in this project, as well as better define the side advantages of the agglomerator on odor, HC, BaP, and sulfate.

II. INTRODUCTION

For many years, the diesel engine has dominated intercity trucking and both intercity and intracity buses. In these applications, the diesel has demonstrated a clear superiority over all other power plants in terms of fuel economy and durability. In recent years, a renewal of interest in mid-range diesels for use in urban delivery trucks has been evident. The basic reason given has been the superior fuel economy. This trend is expected to continue with the real possibility of diesel-powered, light-duty vehicles(LDV's) becoming much more popular. The particulate exhausted from diesels is one of several currently non-regulated emissions that is of concern, especially if the anticipated growth in diesel cars occurs.

A. Background

The Clean Air Act amendments of 1965 were specific in expressing concern over odor and smoke from diesel-powered vehicles. This legislation prompted a long-range investigation of diesel emissions which began in 1966 at Southwest Research Institute's Department of Emissions Research. This continuing activity, currently in its eleventh year, has resulted in a large number of reports and papers on the subject and has formed the basis for a number of other studies regarding diesel emissions on behalf of the Environmental Protection Agency (EPA).(1-28)*

The original project was concerned with visible smoke and noticeable odor, both classed as "nuisance" emissions which interferred with the general welfare. Much was learned in how to measure odor and smoke and the types of conditions which would result in obvious discharges. In the intervening years, a steady broadening of this activity included unburned hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x) (now regulated emissions), methods of control and procedural development.

During the last few years, an increasing variety of non-regulated materials in diesel exhaust have come under scrutiny. Measurement of particulate, aldehydes, polynuclear organic matter, sulfate ($SO_4^=$), sulfur dioxide (SO_2) and several other contaminants have been investigated in an attempt to quantify emissions for which little data is currently available.

Although diesel smoke and particulate have been thoroughly researched, the fundamental combustion mechanisms by which both are formed in a diesel engine are yet largely unknown. Most efforts to collect and remove the particulate, once formed in the combustion chamber, have been failures. The relatively high concentrations of particulate and the large exhaust volumes of the diesel engine used in trucks, for which most research had been directed, were contributing factors to the lack of success. The two controlling factors, however, have been the extremely small particulate size and extremely low effective aerodynamic diameter or density.(29) Not only is diesel particulate "too small" and "too light", there is "too much" for practical collection from the heavy-duty application. Thus, the current "state of the art" of diesel particulate collection and removal is that there is no way to accomplish it effectively.

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* Superscript numbers in parentheses refer to the List of References at the end of this report.

B. Objective

The objective of this project was to evaluate the potential of using combinations of available lead traps for removal of diesel particulate from a diesel-powered car. Lead traps are those items developed for removing products of combustion of lead additive treated gasoline in gasoline-powered cars. The goal was to achieve at least a 50 percent reduction in particulate emission rate and then investigate other aspects such as effect of the removal system on regulated and selected unregulated emissions and potential durability.

The approach was to perform exploratory and evaluative experiments with a Mercedes 300D car using available hardware furnished through the courtesy of those companies that had background and experience in the removal of particulate from the combustion of leaded gasoline. The laboratory effort involved a survey of exhaust system temperatures, screening tests of candidate particulate traps, evaluation of the particulate removal system effect on emissions other than particulate and 16,090 km (10,000 mi) of durability testing.

C. Definition of Particulate

There are many ways to define particulate.(29) For purposes of this project, diesel exhaust particulate was defined as whatever was collected on a Gelman Type A fiber glass filter (47 mm diameter) with a 0.0142 SM^3/min (0.5 SCFM) isokinetic sample rate of air diluted exhaust that does not exceed 52°C (125°F) at the face of the filter and on which water does not condense. Although this definition is contrary to most physical definitions of exhaust contaminants in that it is in terms of the method used, it does adequately describe the material collected. The key item is the air dilution technique which permits collection of the particulate at a relatively low, quite realistic ambient temperature yet without the troublesome water condensate.

D. Project Conferences

In addition to several meetings both at SwRI and at EPA - Ann Arbor with the Project Officer regarding this project, on-site visits by the Project Officer and the SwRI Project Leader were made to the three companies who assisted in this project. The initial visits were to describe the project objective and goal and to enlist the cooperation and obtain available hardware and technical advice necessary to the project.

On September 9, 1975, a meeting was held at Texaco Research Center, Beacon, New York with Mr. Ralph Stahman, EPA Project Officer; Mr. Karl Springer, SwRI Project Leader; Mr. William Tierney and others of the Texaco Research staff in attendance. On September 26, 1975, a similar meeting with Dr. Roy Sugimoto and Mr. John Wisnewski of Houston Chemical Company and Mr. Karl Springer was held in Corpus Christi, Texas. A third such meeting was held on October 13, 1975 with Mr. Dennis Lenane and Mr. Karl Springer at the Ethyl Corporation Research Laboratories in Ferndale, Michigan. A status review meeting with Mr. Tierney and the Texaco staff was held in May 28, 1976 at Beacon, New York, at which time the results of this project were discussed and further assistance requested by the SwRI Project Leader.

E. Acknowledgment

This project could not have been conducted without the cooperation and assistance of Texaco, Inc., Houston Chemical Company, Division of PPG Industries, and Ethyl Corporation. Key individuals who patiently and cheerfully lended themselves were Mr. William Tierney (Texaco), Dr. Roy Sugimoto and Mr. John Wisnewski (Houston Chemical), and Mr. Dennis Lenane (Ethyl). These individuals went out of their way to be cooperative both in preparing and lending hardware items and in the giving of their experience and technical guidance for which SwRI is grateful.

III. DESCRIPTION OF VEHICLE, FUEL, PARTICULATE TRAPS, AND PROCEDURES

This section describes the test vehicle, fuels, particulate traps, test plan and procedures followed.

A. Test Vehicle Description

Table 1 lists particulars that describe the 1975 Mercedes 300D diesel automobile used as the primary test vehicle. The 5 cylinder 300D model was first introduced into the U.S. in 1975 with similar design features but better acceleration performance than its 4 cylinder counterpart. The vehicle was procured from the local Mercedes dealer as a requirement of the contract and is government owned. It was used on the companion work under the basic contract. The results of the vehicle evaluation and emissions characterization were published in the Part VII final report, Reference 28. For additional description of the Mercedes 300D, please see Reference 30, an SAE paper.

TABLE 1. DESCRIPTION OF MERCEDES 300D DIESEL POWERED TEST VEHICLE

Model	300D
Model Year	1975
Vehicle ID	12019885
Type of Vehicle	Sedan
Number of Doors	4
Number of Passengers	5
Color	Brown
Odometer, km	8,106
Number of Cylinders	5
Displacement, litres	3.0
Bore, m x 10^{-2}	9.10
Stroke, m x 10^{-2}	9.24
Compression Ratio	21:1
Output Power, kw	57.4
at rpm	4200
Transmission Type	Auto
Speeds	3
Rear Axle Ratio	3.46
Tire Size	645.14
Empty Weight (Scale), kg	1588
Test Weight (Inertia), kg	1814

B. Test Fuels

Table 2 lists the fuel inspection results of the two fuels used, coded EM-176-F and EM-260-F. The EM-176-F was used until August 25, 1976 and is the same fuel used in Part VII evaluations of the same Mercedes 300D.(28) EM-260-F was used to perform the durability mileage accumulation and subsequent emission testing. Both test fuels were Gulf No. 2 DF-2

TABLE 2. DF-2 FUEL PROPERTIES WITH 1973 BUREAU OF MINES DF-2 FUEL PROPERTIES FOR COMPARISON

		Test Fuels		1973 Bureau of Mines Survey		
Test	ASTM	EM-176-F	EM-260-F	Max.	Min.	Avg.
Gravity, °API	D287	36.4	36.3	36.7	35.8	36.4
Viscosity at 100°F						
Kinematic, CS	D445	2.6	2.59	2.79	2.56	2.67
Saybolt Univ., sec	D88	34.8	34.7	35.3	34.5	34.9
Sulfur content, wt%	D129			0.251	0.192	0.228
	D1266	0.23	0.234			
C residue on 10% wt%	D524			0.110	0.091	0.102
Ash, wt%	D482			0.002	0.001	0.001
Cetane number	D613			48.7	46.9	47.9
	D976	47.6 (1)	48.6(1)			
Distillation temp. °F						
Vol. recovered	D86					
IBP		368	350	378	366	373
10%		424	414	430	423	426
50%		482	493	498	493	495
90%		571	579	580	571	575
End Point		623	642	624	613	620
% Recovery		99.0	99.0			
% Residue		1.0	1.0			
% Loss		0.0	0.0			
FIA,%	D139					
Aromatics		25.6	27.3			
Olefins		2.7	3.2			
Saturates		71.7	69.5			
Flash Point	D93	150	149			

---

(1) Calculated

diesel fuel with sulfur level increased to 0.23 percent sulfur by weight by adding ditertiary butyl disulfide additive. After careful consideration of a variety of fuels, these fuels were selected as being most typical of average fuels in use and, therefore, best able to answer the requirements of this program. This is illustrated by the data in Table 2.

C. Particulate Traps

This subsection describes the various components and systems involved in this project. The object was to evaluate available lead trapping equipment that might have promise for the trapping of particulate from diesel cars. The visits made to the three companies (Texaco, Houston Chemical, and Ethyl), known for their excellence in developing successful traps for removal of lead products of combustion in gasoline fueled automobiles, were all successful in obtaining cooperation and the loan of devices and other assistance in this project. Before describing the specific items, it may be helpful to discuss the general approach taken.

1. Approach

In preparation for this project and prior to the visits with three assisting companies, it became apparent that there were many possibilities for evaluation. In each case, however, for the unit to work, it was felt that it must either agglomerate, separate, or do both functions. The nature of the particulate from diesel combustion is such that any system or combination of components to effect agglomeration and separation will have to function under three very adverse conditions or criteria that describe diesel particulate. They are:

(1) too small
(2) too light
(3) too much

a. Agglomeration

Agglomeration devices can apparently range from large, empty containers in which a simple change in direction occurs to the more sophisticated alumina coated substrates. In between are various types of wire screens, meshes, chopped metal lath that serve apparently as surfaces for impact of particulate on the substrate and on other particles. The surface charge and other surface characteristics of the individual particles are relied on to bring about groupings of many such particles, so that the size and aerodynamic diameter or density is such to allow easier collecting and permanent separation. The agglomerate thus formed is expected to only reside temporarily in the agglomerator and continually and/or periodically break-away through many possible mechanisms and be re-entrained by the exhaust flow in a much larger and hopefully much easier to separate physical state. The so-called "sticky" and "greasy" nature and appearance of some diesel exhaust particulate indicates the presence of many exhaust products other than strictly elemental carbon or lamp black. This, coupled with the relatively low exhaust system temperatures are relied on to make agglomeration work. Without successful agglomeration, there is less chance of diesel particulate removal.

The nature of the light-duty diesel operation, as contrasted with that of a heavy-duty truck, will definitely aid agglomeration by permitting lower exhaust temperatures. There has been some consideration of burning or oxidizing the particulate on the agglomerator or collection device. Again, the measured temperatures of the Mercedes 300D diesel car, even at the exhaust manifold, were so low as to preclude this possibility, even with the more active catalysts applied to the alumina coating. There could be a possibility of "soft" particulate of unburned fuel hydrocarbons, partially oxygenated hydrocarbons and other non-soot particulate to oxidize at the temperatures encountered during light-duty operation.

Catalytic oxidation of carbon with the exhaust temperatures of the Mercedes 300D car would involve a new type of catalyst. The catalyst could also serve to increase fixation of SO_2 to SO_3 and thereby increase sulfuric acid mist. In short, the use of catalytic surface treatments to the agglomerator has possibly more drawbacks than advantages. Accordingly, further study of and possible use of these treatments was deferred until a later project.

b. Separation/Removal

Separation and collection is the other major part of the particulate removal system. Because of the mass of particulate expected, on the order of 0.27 g/km or 21.72 kg (about 48 lbs) in 80,450 km (50,000 mi), the collection and storage of the particulate, assuming 50 percent is indeed separable, is a formidable task. Filters, bags, pleated and other similar arrangements for total removal are excellent for short periods of time but lack the non-plugging feature required for extended operation. Thus, total filtration through membrane type media, bags, etc. as an initial separation system was not considered practical.

Such a method may have some promise as a final removal or cleanup item. Its practicality, even under these circumstances, would depend on the efficiency of the primary separation item. Collection in or immediately after the primary separation method also has its importance since the once separated particles must be automatically collected in a quiescent locale where the exhaust flow will not re-entrain the particulate and purge the system. This type of operation (i.e., store-purge) was not considered satisfactory for the intent of this project.

Separation devices include cyclones, impingers, and swirl tubes, to name a few basic techniques. It was planned to use several size and design cyclone type and swirl tube type components in conjunction with collection techniques/designs normally used with such items in lead trapping. Generally, these collection chambers are small relative to the amount of particulate that is desired to be removed. Since the test plan was mainly proof of principle exploratory type testing, the chamber volume was of no immediate concern. It would be important in the event a specific design would work.

2. Component Description

From the survey of available lead trapping equipment, it was found that both agglomerating devices, separation or removal items and agglomeration-separation/removal systems were available. Some of the agglomeration-separation/removal systems were packaged as a single, "all-in-one" container device, such as a replacement for a conventional exhaust muffler. Table 3 is a brief listing and description of the items of hardware furnished by the assisting companies or by SwRI in conjunction with one of the companies. To assist in describing these items, schematic or cut-away drawings are included in Appendix A through the courtesy of the cooperating companies. Various photographs of the major items evaluated are shown in Section IV "Results" of this report.

D. Test Plan and Procedure

Once the items for test were identified and obtained, the plan of test and experimental procedures followed in four steps.

1. Step 1 - Screening

The individual items and combination systems were screened for their potential ability for diesel particulate trapping. The screening test consisted of connecting the item (or series of items) to the vehicle exhaust and performing three to ten replicate runs. During each run, two 47 mm fiberglass filters were obtained for particulate weight gain. Each run was a full 23-minute urban dynamometer driving schedule (UDDS), commonly known as the LA-4. Most often, the series of runs would include at least one cold start. Only particulate (fiberglass) filters were obtained and no gaseous emissions, smoke, or sulfate, etc. were taken. This allowed the screening of the greatest number of possibilities in terms of individual items as well as combinations. The actual test plan evolved as test data was obtained and after the basic component testing was completed.

The test vehicle conditions were to operate at 1814 kg (4000 lbs) test weight since the curb weight of the Mercedes 300D is 1588 kg (3500 lbs) to which 136 kg (300 lbs) is added according to the Federal Register. Road load included the 10 percent allowance for air conditioning. During all screening tests, the road cooling effect was simulated by using up to six fans in stages to maintain and control the exhaust gas inlet temperatures to the trapping system as close as possible to that measured on the road.

The test plan included replicate tests to evaluate repeatability with both the stock muffler system as well as those trap items that appeared to have promise. Day to day reproducibility as well as vehicle baseline drift were documented by running the stock system periodically throughout the screening part of the project.

As the various components were tried, not only the effect on particulate but the effect on vehicle exhaust system backpressure was noted. The backpressure and temperature measurements were recorded during a series of steady-state cruise conditions. From this initial screening data, the more promising and practical items might be modified and re-run or combined with other promising items to attempt to obtain a system. From this series of component-combination experiments, the best system was identified. This system was then further evaluated in the next step.

TABLE 3. DESCRIPTION OF PARTICULATE TRAP COMPONENTS

Company/ Designation	Description
HCC-115	Combination System Small to Medium 1/8" ± 1/16" Al_2O_3 spheres in packed bed for agglomeration with cylcone for a separator
HCC-115A	Same as HC-115 except larger, nominal 1/4" Al_2O_3 spheres in use
HCC-125	(Plymouth Fury size muffler) advanced combination design was a dual bed agglomerator with parallel-Al_2O_3 spheres in packed beds of nominal 1/4" dia swirl tube separator
HCC-127	Uses a cyclone inlet (tangential) followed by fiberglass filter. Not practical for diesel except as possible final element
HCC-137	Basically an agglomerator that uses small to medium size Al_2O_3 spheres. Can also filter or collect to some extent
HCC	Particulate Filter cylindrically pleated fiberglass used in conjunction with HC-115 as final filter
HCC	Back pack final filter. Contains 0.93 m^2 (10 ft^2) area of fiberglass membrane filter media
HCC	Large Cyclone, large conventional cyclone design
HCC	Medium Cyclone, same design as large
HCC	Small Cyclone, smallest size available, same design
HCC	Swirl tube separator and collection chamber
HCC	Mini swirl tube separator and collection chamber. Smaller unit for higher swirl rate
Ethyl	Agglomerator - Container is packed with chopped lath
Ethyl	TAV (Tangential Anchored Vortex) included two such units, either or both may be used alone or in conjunction with Ethyl agglomerator. TAV is basically a separator

TABLE 3. DESCRIPTION OF PARTICULATE TRAP COMPONENTS (Cont'd)

Company / Designation	Description
Texaco A-1F	Agglomerators - fired alumina coated packed steel wool design 1 front muffler
Texaco A-1R	Agglomerator - fired alumina coated packed steel wool design 1 rear muffler
Texaco A-2R	Agglomerator - same as A-1R but without alumina coating
Texaco A-1M	Agglomerator - cylindrical inconel mesh screen coated with fired alumina in a cylindrical housing similar in design to HC-137, radial flow
Texaco A-1E	Agglomerator - alumina fired on packed steel wool in 10.2 cm (4 inch) stainless steel elbow axial flow

2. Step 2 - Trap System Evaluation

Once a trapping system was found that met the 50 percent reduction goal, then a variety of evaluations were performed.

a. Particulate and Sulfate Evaluations

The one best trapping system was then subjected to a series of particulate and sulfate emissions tests in which the following sequence was run.

(1) FTP cold
(2) 10 minute soak
(3) FTP hot
(4) 10 minute soak
(5) SET
(6) 10 minute soak
(7) FET

Note: 1975 FTP = 0.43 FTP_c + 0.57 FTP_h

This sequence was repeated twice and then the standard muffler system installed and emission tests repeated. In this sequence, the usual Federal Test Procedure was followed using a single fan of 150 m^3/min (5300 CFM) running continuously rather than using staged, multiple fans. A simple gate valve was installed between the vehicle exhaust pipe and the dilution tunnel to simulate the backpressure of 17.8 cm Hg (7.0 in Hg) at 80.5 km/hr (50 mph) at the engine manifold experienced when operating with the standard muffler system.

b. PNA - BaP Emissions

The same test sequence used for particulate and sulfate (Step 2.a. above) was repeated to acquire the larger 20.3 x 25.4 cm (8 x 10 in) fiberglass filters for analysis of benz-alpha-pyrene (BaP), a compound that is indicative of the polynuclear aromatic (PNA) content in the exhaust. A single filter from each type of test was analyzed. The test conditions were identical to those maintained during the particulate-sulfate evaluation.

c. Smoke

The vehicle was operated on the same test sequence as listed in Subheading a. "Particulate and Sulfate", but with the exhaust from the vehicle directed through a U.S. EPA full flow light extinction smokemeter. This separate series of tests involved two each sequences with the particulate trap system and one such sequence with the standard system at simulated backpressure of the trap system. All other operating conditions were in accord with the Federal Test Procedure in terms of cooling fan, inertia weight and road load settings.

d. Gaseous Emissions

Following the particulate and sulfate test series in Step 2.a. above, the gaseous emissions of unburned hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), DNPH aldehydes, non-reactive hydrocarbons (NRHC) and diesel odor analytical system (DOAS) traps and fuel economy were obtained. The following sequence was run:

(1) 1975 FTP from cold start
(2) 10 minute soak
(3) SET
(4) 10 min soak
(5) FET

The above sequence was repeated twice, with trap system installed, for usual gaseous emissions of HC, CO, NO_x, fuel economy and DOAS. Only one such test sequence was sampled for DNPH aldehydes and NRHC. Then, the factory system was installed and the test sequence run twice, but at normal standard exhaust system backpressure of nominal 2.54 cm Hg (1 in Hg) at 80.5 km/hr (50 mph) at the engine manifold. Both groups of tests were made with the single continuously operated cooling fan per the 1975 Federal Test Procedure.

e. Odor and Related Measurements

A five day odor test series using the trained SwRI odor panel was performed. The first three days were with the trapping system installed, while the last two days were with the standard exhaust system (one day at normal "low" backpressure and one day at the backpressure consistent with the particulate trap system.

Each day included the cold start and then seven steady-state conditions run in replicate (three times) randomly. Simultaneous with the steady-state runs, DNPH aldehydes were sampled and composited to give seven samples. DOAS traps were taken (21 samples) and NRHC (seven typical conditions) were obtained along with the usual HC, CO, NO_x, CO_2, etc. of the raw exhaust. Except for DNPH aldehydes, which were obtained once with the trap system and once with the standard system ("low" backpressure), gaseous emissions were obtained during all steady-state runs on the last two days of trap and both days of the standard system.

In the afternoon of each odor testing day, three transient conditions were analyzed by the odor panel with four replications each. No gaseous or other emission measurements were taken during the transient runs.

f. Noise

Exterior sound level measurements were taken during the prescribed SAE J-986a with the trap-equipped vehicle for comparison to measurements taken earlier during Part VII.(28) Interior and exterior measurements were also taken during constant speed drivebys and during curb idle.

g. Performance

Acceleration performance, in terms of the time required to accelerate from

(1) 0 - 64.4 km/hr (0 - 40 mph)
(2) 0 - 96.5 km/hr (0 - 60 mph) and
(3) 32.2 - 96.5 km/hr (20 - 60 mph)

were measured with the trap system installed for comparison to previous, similar data with the standard system.(28)

3. Step 3 - Durability

The test plan was to accumulate up to 16,090 km (10,000 mi) or until the system durability or effectiveness deteriorated. The test mileage was to be accumulated using the Motor Vehicle Manufacturers Association (MVMA) 11-lap test course specified by the Federal Register for light-duty vehicle emissions durability purposes. The SwRI test course, shown in Figure 1, was run at 88.5 km/hr (55 mph) top speed in accordance with EPA Mobile Sources Advisory Circular No. 37, dated December 20, 1973. Lap 11 is a series of wide-open throttle (WOT) accels to 88.5 km/hr (55 mph); and no modification was made to this procedure even though for sulfate durability work, the accelerations have been limited to normal part throttle driving habits.

The plan involved periodic particulate testing at 4023 km (2500 miles), 8045 km (5000 miles), 12,068 km (7500 miles) and 16,090 km (10,000 miles) of MVMA durability. These particulate tests consisted of a series of 3 hot 23 min UDDS cycles in succession. At 8045 and 16,090 km, the plan called for tests for particulate, using the test sequence in step 2.a. in both the trapping system and standard exhaust configurations. Only particulate measurements were taken. Two cold start days were made with each system.

E. Analytical Methods

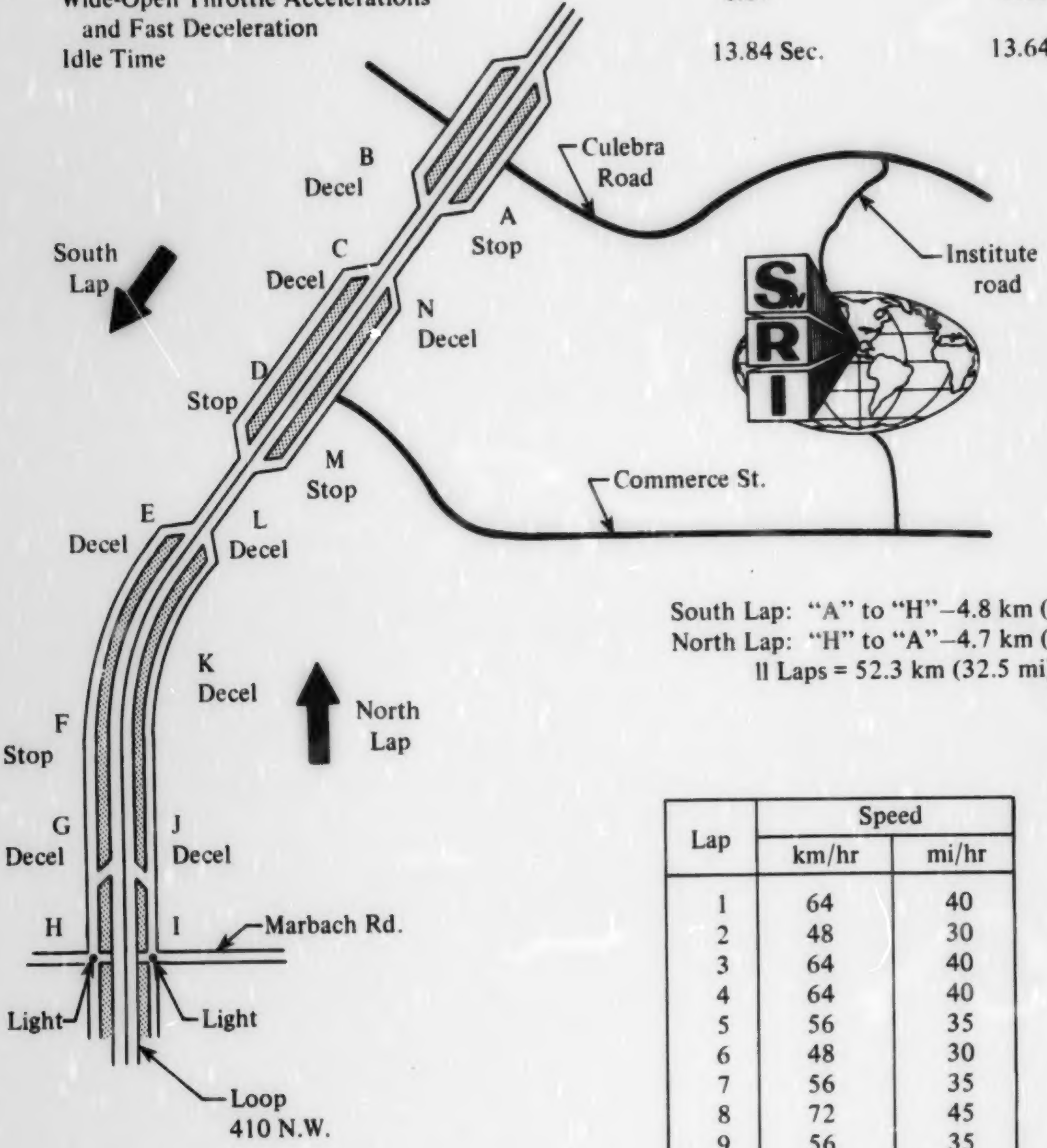
The best reference, and one that is relied on in this report to describe the analytical methods, is that given in the Part VII final report, Reference 28. Rather than repeat in detail the analytical procedure descriptions given in Reference 28, the methods critical to this project will be described in some detail and summary descriptions of other techniques given with suitable referencing.

1. Particulate

This was the most pertinent of all measurements made as this was the basis for success of the project. The mass rate of emission of particulate was determined by collecting a known amount of particulate matter on a preweighed glass fiber filter. The 47 mm diameter Gelman Type A glass fiber media was the principal size and type of filter disc employed. Particulate mass rates were also obtained using both an 8 x 10 size fiberglass filter for polynuclear aromatic (PNA) compound analysis and by Fluoropore (Millipore Corp.) 47 mm plastic filter media with 0.5 micron mean pore flow size for sulfate collection.

The basic technique for sample collection was to dilute the exhaust with prefiltered air much the same as the constant volume sampler

	Events Per Mile	
	55 mph Top Speed	
Driving Mode	SwRI Course	AC No. 37
Stops	1.02	1.01
Normal Accelerations from Stop	0.92	0.91
Normal Accelerations from 20 mph	1.11	1.11
Wide-Open Throttle Accelerations and Fast Deceleration	0.09	0.10
Idle Time	13.84 Sec.	13.64 Sec.


Culebra Road
B
Decel
A
Stop
South Lap
C
Decel
N
Decel
Institute road
D
Stop
M
Stop
Commerce St.
E
Decel
L
Decel
K
Decel
North Lap
F
Stop
G
Decel
J
Decel
H
I
Marbach Rd.
Light
Light
Loop 410 N.W.

South Lap: "A" to "H"–4.8 km (3.0 mi)
North Lap: "H" to "A"–4.7 km (2.9 mi)
11 Laps = 52.3 km (32.5 mi)

Lap	Speed	
	km/hr	mi/hr
1	64	40
2	48	30
3	64	40
4	64	40
5	56	35
6	48	30
7	56	35
8	72	45
9	56	35
10	89	55
11	89	55

FIGURE 1. MVMA DURABILITY MILEAGE ACCUMULATION DRIVING COURSE

(CVS) does with the exhaust in the LDV-FTP for gaseous emissions. The definition of particulate was in terms of the dilution and collection media and, importantly, the temperature at the point of filtration. In keeping with EPA definition of particulate from Reference 27, anything that was collected on Type A glass at a temperature not to exceed 51.7°C (125°F) other than condensed water was considered diesel particulate. The particulate thus included aerosols and unburned fuel-like matter.

The nominal 0.457 m (18 inch) diameter by 4.88 m (16 ft) long dilution tunnel used to dilute and cool the exhaust is shown in the Figure 2 schematic drawing. The pertinent dimensions, flows, velocities, and the relationship of the various components which make up a particulate collection system are indicated. A micro balance, with 1 microgram accuracy and housed in a special humidity, temperature controlled environment, was used to weigh the filters before and after the test. The weighing box is supplied with pre-filtered scrubbed air at a constant 22.2 ± 0.6°C (72 ± 1°F), 10.6 ± 0.3 g/kg (74 ± 2 grains/lb dry air) humidity at 0.3 m^3/hr (10 CFM).

The dilution tunnel was quite capable of handling the entire exhaust from the Mercedes 300D diesel powered car without exceeding the 51.2°C (125°F) sample temperature. The dilution tunnel nominal flow of 14.15m^3/min (500 CFM) was not excessive in overdiluting necessarily but is greater than would normally be used in a gaseous emissions test by conventional CVS technique.

In order to achieve a sufficient sample and because there is no convenient means to switch particulate samples at the 505 second point in the city driving schedule, all cold start FTP's were for the entire 23 minutes on a given filter. The ten minute soak period was then observed and then an additional full 23 minute city driving cycle repeated from a hot start. The other two transient driving cycles were from a hot start with the sample for the SET and for the FET collected on separate filters.

The four sample systems permitted the collection of two (2) each particulate samples on 47 mm glass and when required two (2) each sulfate samples on 47 mm Fluoropore media. The testing sequence of cold-hot FTP, SET and FET was repeated on several successive days. This test sequence was then performed with the high-vol sampler to obtain larger amounts of particulate for PNA analysis using the 8 x 10 size glass filters.

The various photographs in Figure 3 show the dilution tunnel in use with the Mercedes 300D car. The dilution tunnel was located alongside the car, as shown in the two top and lower right views. The positive displacement blower and the four sampling filter system is shown in the upper and center left views. Figure 4, upper left view, shows the four probe assembly for the 47 mm filters and the larger, single, 8 x 10 size filter. An overall view of the dilution tunnel is shown in the upper right view. The two center views show the background filter holder (left) and the insertion of a 47 mm glass filter on one of the filter holders of the 4 probe system.

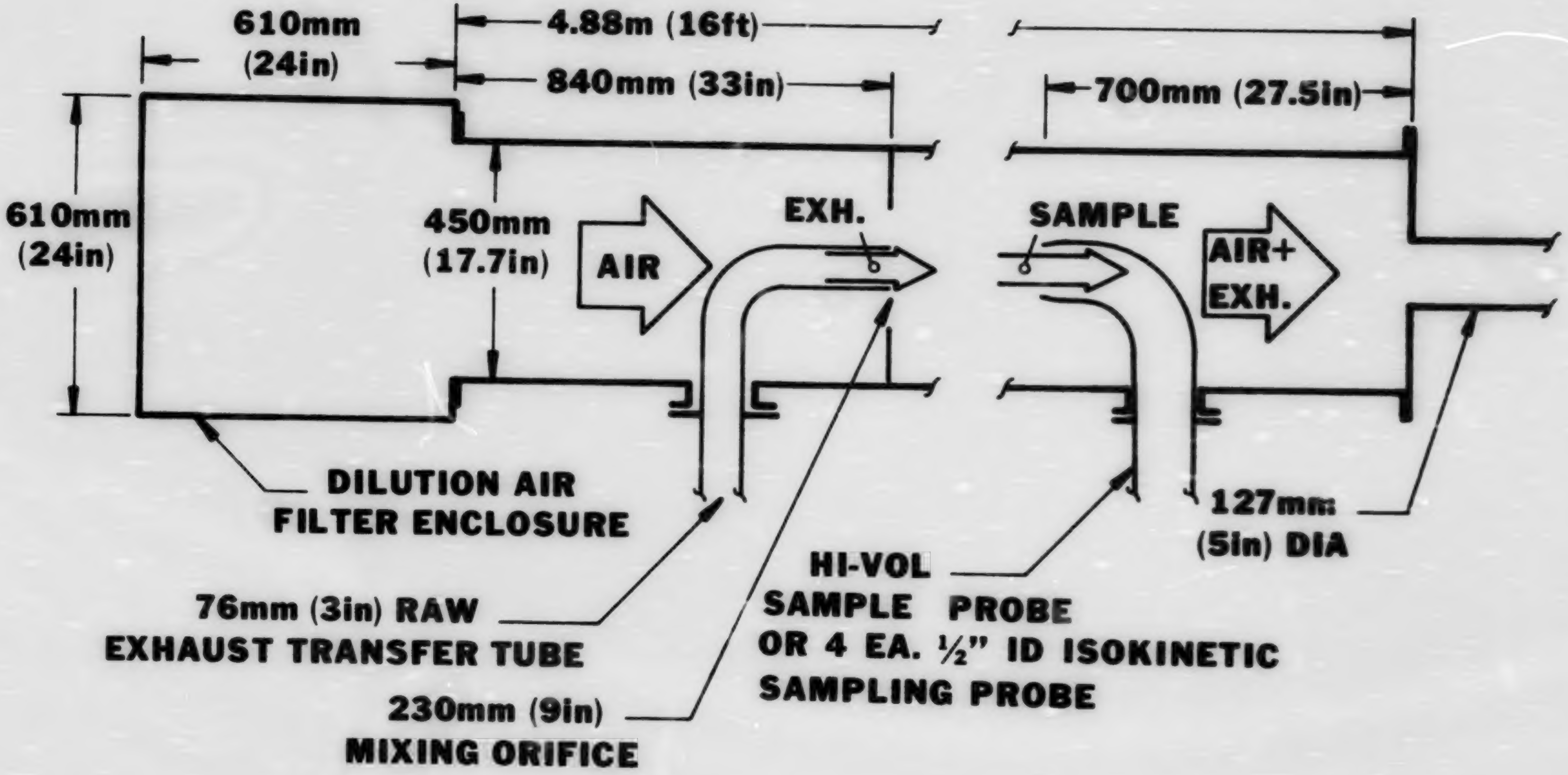

610mm
(24in)
4.88m (16ft)
840mm (33in)
700mm (27.5in)
610mm
(24in)
450mm
(17.7in)
AIR
EXH.
SAMPLE
AIR+
EXH.
DILUTION AIR
FILTER ENCLOSURE
127mm
(5in) DIA
HI-VOL
SAMPLE PROBE
OR 4 EA. ½" ID ISOKINETIC
SAMPLING PROBE
76mm (3in) RAW
EXHAUST TRANSFER TUBE
230mm (9in)
MIXING ORIFICE

FIGURE 2. SCHEMATIC SECTION OF DILUTION TUNNEL FOR DIESEL PARTICULATE SAMPLING

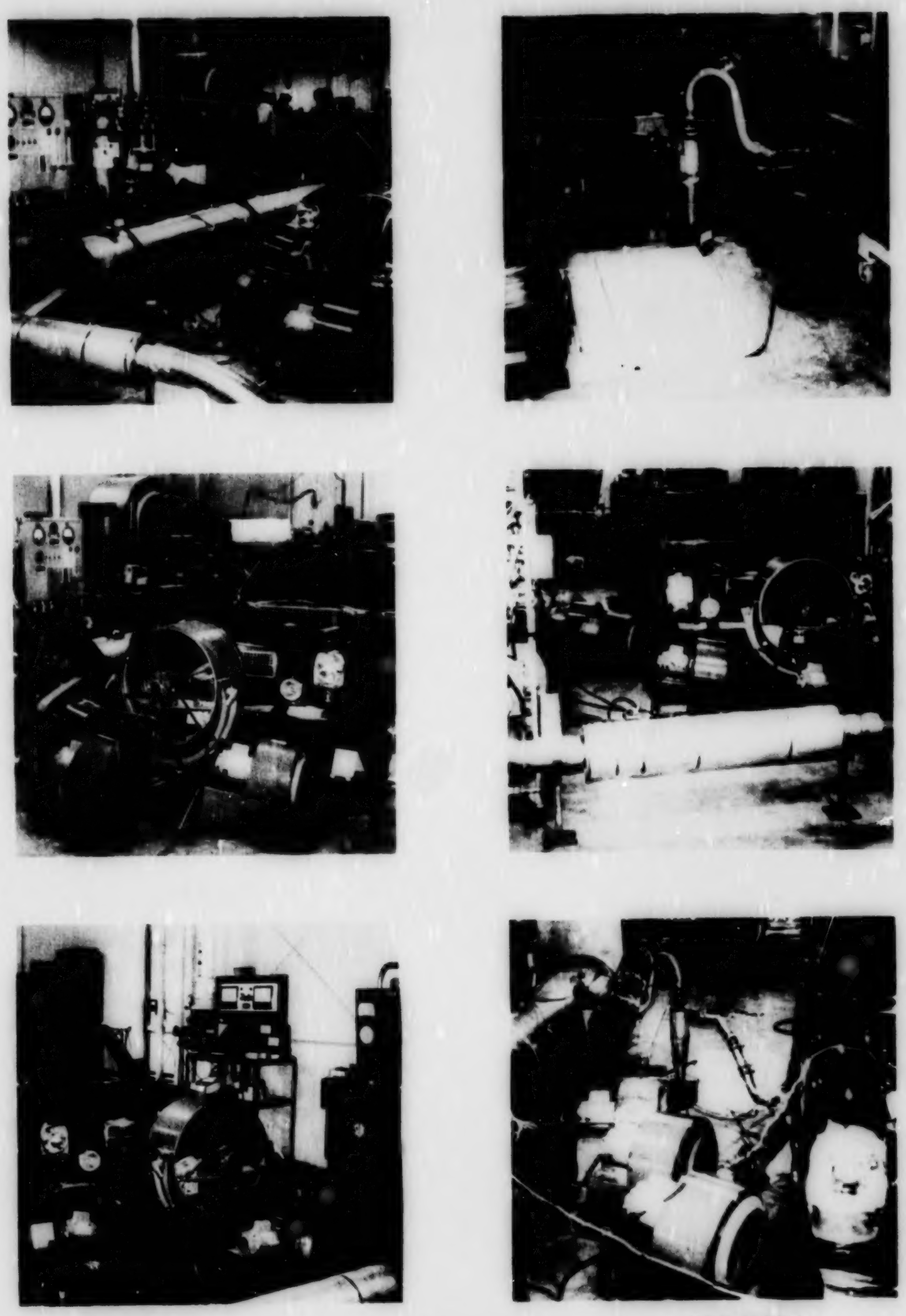


FIGURE 3. EQUIPMENT ARRANGEMENT FOR PARTICULATE TRAP TEST AND EVALUATION

FIGURE 4. PARTICULATE TUNNEL AND RELATED EQUIPMENT

The lower left view of Figure 4 shows a used 8 x 10 size filter and new and used 47 mm glass and Fluoropore filters. The small disc to the far right in this photograph is the Fluoropore filter used for sulfate. The lower right photograph shows the humidity and temperature controlled environmental chamber in which the before and after weights were determined to 1 microgram sensitivity.

2. Sulfate

The barium chloranilate (BCA) method for analysis of sulfuric acid mist (sulfate) in gasoline exhaust has been well documented. Its use with diesel engines, both light and heavy duty, was described in Part VII final report, Reference 28. Sulfur dioxide (SO_2), important for a sulfur balance, was not measured in this project. Satisfactory sulfur balance was obtained for the Mercedes 300D test car during the Part VII evaluation.(28) Validation of the sulfate analysis method was described in Reference 28. The lower right view in Figure 5 shows the BCA and Beckman UV spectrophotometer instrumentation used.

3. Polynuclear Aromatic Matter - PNA

PNA compounds as a class and as individual contaminants were of interest in this project. Although there are several laboratory procedures available for their analysis, the major difficulty was analysis of PNA materials in diesel exhaust and of equal importance, the collection of a sample in a form suitable for such laboratory analysis. The current state-of-the-art in diesel PNA analysis is undergoing fairly rapid change, there being much concern over current available techniques. For lack of a better method, a thin layer chromatography method(32) for analysis of BaP was used. This is the method used in the latter part of the Part VII effort and is described in detail in Reference 28.

An 8 x 10 size fiberglass filter was needed to collect sufficient particulate for BaP analysis. The extractions and analyses were performed by the Southwest Foundation for Research and Education, the sister institution to SwRI.

4. Elemental Analysis

Determination of carbon, hydrogen, and nitrogen weight percentages in diesel particulate were performed by Galbraith Laboratories. Carbon and hydrogen were measured using ASTM method D-3178 and nitrogen was measured using ASTM D-3179. The results were corrected for blank filter content, which was reported to be very low. Sulfur analyses of the particulate were performed by X-ray fluorescence.

5. Smoke

There is currently no recognized U. S. smoke test procedure for light duty passenger car exhaust. Although the heavy duty schedule of speed and load versus time can be used with the light duty vehicle by a chassis dynamometer version of the test, it is uncertain whether this test is indeed representative of the way the smaller, higher speed diesels

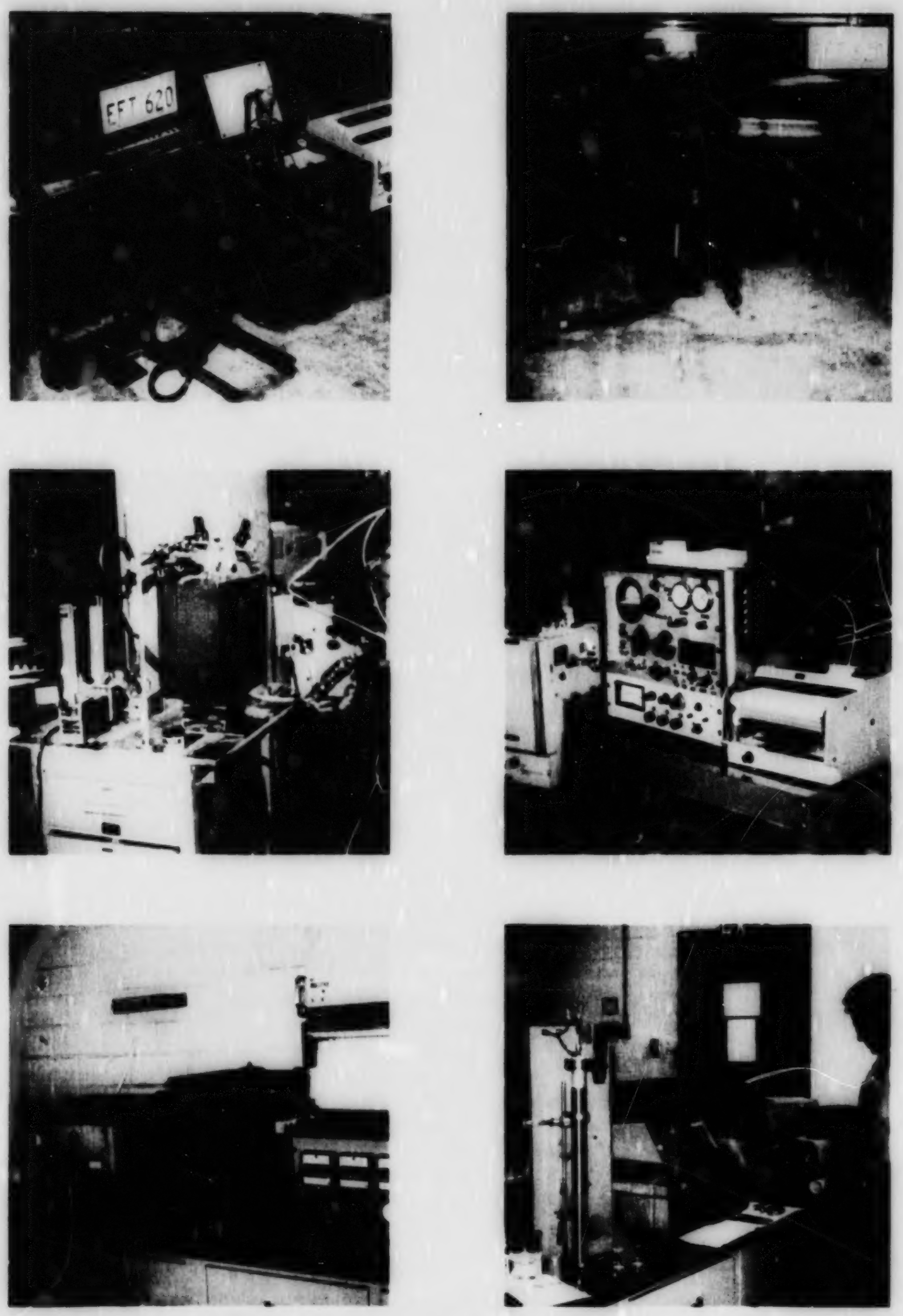


FIGURE 5. SMOKE AND GASEOUS EMISSIONS FROM MERCEDES 300D DURING TRANSIENT CYCLES

operate. Specifically, engine rated speed, that engine rpm when maximum brake horsepower occurs, is considered higher than that normally encountered in passenger cars in urban use. The visible smoke emission from the Mercedes 300D was continuously recorded during operation of the vehicle over the three transient driving cycles (FTP, SET, FET) but with the CVS disconnected. These cycles will be described in the next section.

The two top photos of Figure 5 show the Mercedes 300D with standard exhaust system (left) and the Ethyl TAV separator (right), as prepared for the smoke tests. Note in both cases a short 0.61 meter (24 inch) exhaust pipe extension of 50.8 mm (2 inch) exhaust pipe was used. The PHS smokemeter is mounted at the end of this pipe so that the centerline of the light beam is 127 mm (5 inches) from the tip of the pipe. The usual light duty water brake Clayton 50 hp chassis dynamometer with belt drive inertia system was employed. A two-pen strip chart recorder was used to monitor smoke opacity and vehicle speed. The usual driving aid was used to drive the transient LA-4, SET or FET speed versus time trace.

6. Gaseous

The cold start 1975 FTP was the basic transient procedure used for measurement of gaseous emissions of HC, CO, NO_x as well as for fuel economy. The diesel procedure was originally described in Reference 33 and modified in later Federal Registers. Hydrocarbon values were obtained by the continuous hot flame ionization analysis.(9) The Federal Test Procedures for gaseous emissions were followed without exception. No evaporative hydrocarbon tests were made.

In addition to the usual HC, CO and NO_x measurements, samples were continuously taken and collected in reagents for wet chemical analysis or in suitably packed traps for later odor analysis. These samples were withdrawn in the stainless steel pipe section connecting the exhaust dilution point (below the CVS filter box) and the CVS inlet. Several probes were inserted into this pipe section, one probe for the DNPH bubblers and one for each of the three odor trapping systems for the diesel odor analytical system (DOAS). These probes were located adjacent to the probe used to obtain the continuous HC sample. All sample lines and interfaces were heated as required to maintain sample integrity for diesels. HC sampling and diesel odor analytical systems (DOAS) traps were taken at gas temperatures of 191°C (375°F). Aldehyde samples were obtained by use of large glass bubblers immersed in ice water.

A digital integrator was used to integrate the time-concentration signal from the HC analyzer, a flame ionization detector with linear response. The other continuous samples depended on their absorbing materials, reagent for wet collected samples, and chromosorb in the case of the diesel odor traps to integrate a total representative sample for the entire 1975 FTP. It should be understood that each FTP included the standard three separate bags for gaseous emissions. The integrator for HC was wired to give three separate integrations.

In the case of wet collected and odor traps, the entire 23-minute (Bags 1 and 2) and the third bag 505-second portion of the 1975 FTP were taken in a single collector (bubbler or trap). This was necessary to obtain sufficient sample for analysis and preclude the problem of switching after the first 505 seconds of the run (cold start bag).

All runs were made with the CVS main blower slowed to a nominal 5.38 m^3 per minute (260 CFM). The reason was to prevent overdilution of the already air-dilute exhaust and maintain the sensitivity of analysis. No problems were encountered by operating at this lower-than-normal speed once the CVS was calibrated and propane checked. The two center photographs of Figure 5 show the test set-up used. Shown is the CVS, HC oven, and analyzer sections and trapping interfaces for aldehydes and DOAS.

7. Odor and Related Instrumental Analyses

The following are brief descriptions of the analytical methods used during the odor evaluations.

a. Evaluation by Trained Panel

The EPA (PHS) quality-intensity (Q/I) or Turk kit method of evaluation of dilute samples of diesel exhaust odor(34) was employed to express odor judgements by the trained ten-person SwRI odor panel. The kit, shown in the upper left photo of Figure 6, includes an overall "D" odor in steps 1 through 12, (12 being strongest) that is made of four sub-odors or qualities. These comprise burnt-smokey "B", oily "O", aromatic "A", and pungent "P" qualities each in a 1 through 4 intensity series, 4 being strongest. Special odor sampling, dilution, and presentation facilities(1,2) for diesel odor research were developed ten years ago using design criteria obtained in field studies of atmospheric dilution of bus and truck exhaust. Horizontal exhaust at bumper height from a city bus was found to be diluted to a minimum reasonable level of 100:1 before being experienced by an observer. This dilution level was used in the odor test of the Mercedes 300D, although it is uncertain that this is the reasonable minimum dilution level from a diesel powered passenger car. References 1 and 4 describe the odor facility and References 2, 3, and 4 describe the development of procedures and operating conditions for research purposes.

The top right view of Figure 6 is of the odor room and panel. The center left view shows the instrumentation for HC, CO and NO_x while the center right view is of the DOAS sampling/trapping interface. The lower left view is of the DNPH analytical instrumentation. The lower right view shows the DOAS liquid column chromatograph.

b. Odor Test Conditions

The odor measurement procedures applied to the diesel powered cars was in keeping with that used in Part VII(28), and was based on the extensive previous work with diesel exhaust odor measurement from other light and heavy duty diesel vehicles. The basic philosophy was to characterize odor over a range of loads and speeds that could be encountered to include steep uphill plus moderate trailer towing as well as moderate load and no load conditions.

FIGURE 6. ODOR AND RELATED EXHAUST EMISSION MEASUREMENTS

Table 4 lists pertinent operating data for each of the test conditions. The steady state runs were made at three power levels, normally zero, mid and high power at a high and at an intermediate speed. The seventh condition was a low idle of a well warmed-up engine. Mid-load was defined as a fuel rate midway between the fuel rates at full and no load (transmission in neutral). These seven conditions were performed in random order so as to replicate each condition three times for a total of 21 runs. Cold start odor ratings were taken at the beginning of each day's testing.

In accord with the Project Officer, high speed was defined as the engine rpm corresponding to 90.1 km/hr (56 mph) level road load. This gave a top engine speed of 2900 rpm. The intermediate speed was then defined as 60 percent of this speed, which was 1740 rpm, giving an intermediate vehicle speed of 53 km/hr (33 mph).

In the afternoon, an acceleration after upshift, a deceleration after a cruise, and an acceleration after idle from rest, were run. These three transients were replicated in random order four times, for a total of twelve transients per afternoon. In practice, the level road load, defined for a specific car test weight given in the *Federal Register*, was set in the dynamometer at 80.5 km/hr (50 mph). This road load plus an appropriate sized inertia wheel was employed to simulate the acceleration and deceleration performance of the vehicle.

The acceleration after prolonged 1 minute idle normally involved evaluation during a rapid wide-open throttle (WOT) acceleration in low drive range. The odor was evaluated at nominally 24.1 km/hr (15 mph), 3150 rpm which was reached at 3.5 seconds after start of the acceleration. The acceleration was generally made in high gear after upshift and began at 40.2 km/hr (25 mph) requiring 7.5 seconds. The deceleration was from 80.5 km/hr (50 mph) to 48.3 km/hr (30 mph) with evaluation at 56.3 km/hr (35 mph) at 96.5 seconds after closed throttle (CT). In all transients, the LD FTP road load was present in the water brake dynamometer at 80.5 km/hr (50 mph).

c. Gaseous Emissions

Gaseous emissions were also taken during the steady-state, speed-load odor maps. Measurements included HC by heated FID, CO_2, NO and CO by NDIR, NO and NO_x by chemiluminescence (CL), oxygenates, and various NRHC. The seven conditions, in triplicate (21 runs) were repeated on two mornings normally separated by one day for analysis and preparation.

These measurements were intended to define the steady state performance and characterize emissions beyond that possible from the LDV transient procedures. Also, the data would be useful in comparison with and correlation to the odor panel ratings and other measurements by the CAPE-7 DOAS instrument. Figure 6, left center view, shows the gaseous emissions instruments utilized in this category of tests.

TABLE 4. ODOR TEST CONDITIONS

		Steady State Operation
Engine High Speed, rpm		2900
Engine Inter Speed, rpm		1740
Engine Idle Speed, rpm		640
Fuel Rate High,(1)	high speed	11.3
(kg/hr)	inter speed	4.0
Mid,(1)	high speed	7.5
	inter speed	2.0
No,(1)	high speed	3.7
	inter speed	1.9
Idle		0.5
Drive Gear,	high speed	D-3
	inter speed	D-3
Vehicle km/hr at	high speed	90.1
	inter speed	53.1

		Transient Conditions
Idle-Accel km/hr,	start	0
	end	31.4
Driven in		D-1
Odor Test	rpm	3150
	km/hr	24.1
Accel time, sec.		3.5
Accel Range, km/hr	start	40.2
	end	80.5
Driven in		D-3
Odor Test	rpm	3170
	km/hr	72.4
Accel time, sec.		7.5
Decel range, km/hr,	start	80.5
	end	48.3
Driven in		D-3
Odor Test	rpm	2800
	km/hr	56.3
Decel time, sec.		9.6

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(1) Denotes fuel rate at high load, no load and a load midway between a high and no road load

d. Partially Oxygenated Compounds - DNPH

In keeping with Part VII, aldehydes were measured by the 2, 4-dinitrophenylhydrazine (DNPH) method. The DNPH method, described in Reference 28, was recommended by EPA-RTP as being more valid for diesel work than the previously used MBTH method. Wet collection traps are used, a GC is employed, and there are many intermediate steps in the preparation of the sample once collected relative to the previously used method.

Seven separate samples were obtained. Each sample contained the three replications and represented 12 to 15 minutes of sample absorption in the glass bubbler trap system with 4 to 5 minutes of trapping each run. The seven runs were made on the first day of the two day sequence for each vehicle configuration. The lower left photo in Figure 6 shows the DNPH analytical instrumentation.

e. Characterization of Non-Reactive Hydrocarbons

The measurement of non-reactive hydrocarbons (NRHC), was performed using a gas chromatograph procedure developed by EPA (RTP).(35) This procedure uses a single flame ionization detector with a multiple column arrangement and dual gas sampling valves. The timed sequence selection valves allow for the baseline separation of air, CH_4, C_2H_4, C_2H_2, C_3H_8, C_3H_6, C_6H_6 and C_7H_8. Although only CH_4, C_2H_6, C_2H_2, C_3H_8, and C_6H_6 are considered non-reactive, C_2H_4, C_3H_6 and C_7H_8 were determined during the course of the analysis. Only the non-reactive hydrocarbons are used in the calculation of NRHC emission rates, but all individual hydrocarbon data is useful in the emissions characterization.

Samples were obtained directly from the bag samples of FTP, SET and FET transient cycles and the 7-modes used during all odor testing and analyzed in the NRHC system. Individual NRHC values were determined and a NRHC value for the bag or run was calculated. This value was then used to determine the NRHC emission rates for these tests. By knowing the NRHC and HC emission rates, it was possible to determine the fraction of NRHC in the total HC. A detailed description of the individual columns, temperature, flow rates, etc. may be found in Reference 34. The lower left photo in Figure 5 illustrates the NRHC analytical instrumentation that was used for this analysis.

f. Diesel Odor Analytical System

As one result of approximately five years of research, sponsored under the CAPE-7 project of CRC APRAC, A.D. Little developed a prototype liquid chromatograph for use in predicting diesel exhaust odor. Called DOAS for diesel odor analytical system, the system provides two results, one being an indication of the oxygenate fraction called LCO for liquid chromatograph oxygenates, and the other called LCA for liquid chromatograph aromatics. These were found by earlier research by ADL to represent the major odorants in diesel exhaust. The ADL studies had shown a correlation of the TIA (total intensity of aroma) to sensory measurements by the ADL odor panel. TIA is equal to $1 + \log_{10}$ LCO.

Both LCO and LCA are expressed in micrograms per liter of exhaust using either the test fuel or a reference component for calibration. The CO is, by virtue of its use to express TIA, considered the most important indication of diesel exhaust odor by this method. An entire series of reports have been published by ADL describing their work with diesel odor.(36-40) Reference 40 describes the DOAS and its use, while Appendix C in this same reference describes the sample collection procedure. Rather than repeat these instructions, this section will describe how the system was employed in this series of tests. The lower right view of Figure 6 is of the DOAS instrument.

To obtain DOAS samples required odor test mode times of 6 minutes to allow up to 5 minutes of trapping. The first minute was to achieve a stable operating speed and load. Panel evaluation is normally during the third minute of the run. No serious problems of tire or engine overheating were encountered with this schedule.

The sampling interface system, shown by the center right photo in Figure 6, follows good laboratory practice as applied to diesel hydrocarbon measurement. Most of the sampling system was housed in an oven held at 190°C (376°F). Additional details of this sampling interface are given in Reference 28.

When operating the Mercedes 300D on the 1975 FTP transient LA-4 test, it was estimated that the long sampling time of 31.4 minutes would compensate for the intentionally diluted (estimated 5 to 7:1) exhaust by the CVS method. Recall the dilution level was held to a minimum to prevent over-dilution of the already air-rich diesel exhaust.

g. Vehicle Noise

This series of tests was intended to determine the maximum interior and exterior sound levels, in dBA scale, during idle and various driving modes. SAE J986a, "Sound Level for Passenger Cars and Light Trucks," describes a test procedure that formed the basis for measurement and vehicle operation. A General Radio Type 1933 Precision Sound Level Analyzer, General Radio Type 1562-A Sound Level Calibrator, and General Radio Wind Screen, meeting the requirements of International Electrotechnical Commission Publication 179, were used. Please refer to Reference 28 for a more complete description of the noise test as well as data on several diesel-powered cars.

IV. RESULTS

This section describes the findings of this project and includes subsections dealing with the road-exhaust system temperature survey, screening tests of traps components, evaluation of the trap system and durability operation.

A. Road-Exhaust System Temperature Survey

Preparatory to evaluation of the particulate trapping devices, it was necessary to determine the exhaust system temperatures of the Mercedes 300D. The exhaust system temperature has an influence on component selection and location. More importantly it has an influence on collection efficiency and what is collected as well as what is retained. It is a complicated effort because the particulate is a complex mixture of aerosols (soft particulate) and solids (hard particulate).

For example, sulfate is a part of the particulate in diesel exhaust with about 2 percent of the fuel sulfur converted and exhausted as sulfuric acid mist. The effect of lower temperatures on the collection (storage) and higher temperatures on purge (removal) means that the particulate trap probably should be at the coolest part, the end, of the exhaust system. This would also be the case for unburned fuel or partially burned fuel and/or lubricating oil. However, some of these products may be burnable if the proper conditions existed, one of which is sufficient heat. This means the particulate trap should be located at the hottest point in the system, immediately after the engine exhaust manifold.

The major component in most diesel exhaust particulate is not aerosols, but is solid particulate in the form of lamp black, soot or ash residue. The carbonaceous material requires substantial energy to ignite, once exhausted from the combustion chamber. Therefore, location of the trap is of less consequence with respect to system temperature. The collectability of the solid particulate is likely a function of the other particulate aerosols and temperature. For example, some diesel particulate is greasy and sticky, inferring such a possibility. By locating the trap in the coolest region of the vehicle exhaust system, advantage might be taken of a possible combination effect and improve collection efficiency.

The above discussions are meant to indicate the importance exhaust temperatures played in this project. It is known from experience that the single 150 m^3/min (5300 CFM) cooling fan required in the 1975 FTP emissions test does not necessarily simulate the vehicle exhaust temperatures of the road. It serves to bring air to the vicinity of the front of the car and radiator and thereby promote sufficient cooling of the engine during the emissions test. For screening tests of particulate traps, this single fan was unsatisfactory. How much additional cooling and where to effect the vehicle cooling in the chassis dynamometer laboratory was unknown chiefly because the exhaust system temperatures during road operation were unknown.

1. Road Temperature Survey

The road temperature surveys thus had the goal of defining the exhaust system temperatures over various driving cycles to allow their simulation during driving of these same cycles in the laboratory on the chassis dynamometer. To overcool or undercool during trap screening would result in distorted or possibly an incorrect evaluation.

Figure 7 shows various views of the Mercedes 300D prepared for the temperature survey. The two top photographs show the "fifth" wheel used for vehicle speed (left view) and the bumper level ambient air thermocouple (right view). The two center photographs show the six pen temperature recorder, the temperature integrator and the digital temperature read-out. Not shown are the power supplies, the driving aid and related "fifth" wheel accessories in the front seat of the car. The lower left photo shows the location of the under-hood thermocouples at the exhaust manifold flange, water out, air intake manifold and crankcase oil. Not shown are the various thermocouples placed in the exhaust system.

Three technicians were required to acquire the field data. The driver did not steer the car but applied power and brake normally to achieve the speed versus time driving profiles of the UDDS (LA-4) featured in the FTP, the SET (S-7 cycle) and the FET. The right front seat technician actually steered the vehicle down a long, straight, flat stretch of little used Texas highway. The right rear seat technician operated the instruments and recorded temperatures from the digital temperature read-out. The key to simulation of the transient driving cycles was to use the fifth wheel speed signal as the dynamometer speed signal and match this speed to that required on the pre-printed driving aid just as would be done if the car were on a chassis dynamometer.

The most critical exhaust temperatures, those which changed most rapidly, were recorded continuously while others, such as engine water, oil, air intake were recorded manually at periodic intervals during each run. In addition to the FTP, run from hot start, SET and FET, data at 48.3 km/hr (30 mph) and at 96.5 km/hr (60 mph) steady state cruise were obtained. Table 5 is a summary of the temperature profile data taken during the UDDS of the 1975 FTP. The runs were from a warmed-up vehicle condition and represented operation in one direction for run 1 and then in the opposite direction for run 2. The temperatures are fairly explanatory with the table footnotes explaining whether the values were from the continuous trace or whether taken manually from the digital indicator. The most important finding was the exceptionally low exhaust system temperatures measured. Even though the bumper ambient was 31°C (88°F), all the exhaust temperatures were below a maximum of 528°C (1011°F), at the engine exhaust manifold. The average engine exhaust manifold temperature was about 190°C (374°F) over the 23 minute long UDDS (FTP) test cycle. This means that the relatively higher temperatures, of say above 250 to 300°C, were encountered very briefly and that the temperature profile was greatly skewed to the lower end of the 528-120°C max-min range.

At the other extreme of the exhaust system, some 4 m (157 inches) from the engine, the exhaust outlet temperature of the rear muffler was

TEXAS
EFT·620

FIGURE 7. MEASUREMENT OF EXHAUST TEMPERATURES DURING ROAD AND CHASSIS DYNAMOMETER DRIVING CYCLES

TABLE 5. MERCEDES 300D ROAD AND CHASSIS DYNAMOMETER TEMPERATURE PROFILES
1383 sec, 12.07 km, FEDERAL LIGHT DUTY TEST (FTP)

Reading	Road			Dyno		
	Run 1	Run 2	Avg.	Run 3$^{(4)}$	Run 4$^{(5)}$	Run 5$^{(6)}$
Exhaust Manifold, °C$^{(1)}$	190 (544-120)	190 (528-136)	190	180 (376-144)	180 (396-148)	180 (416-151)
Integrator, °C	---	---	---	177	178	182
Pipe Flange, °C$^{(1)}$	175 (440-143)	175 (433-153)	175	170 (365-133)	170 (438-130)	170 (407-133)
Muffler 1 Inlet, °C$^{(1)}$	170 (335-135)	170 (345-139)	170	165 (313-123)	165 (338-125)	165 (355-130)
Integrator, °C	165	172	169	156	158	164
Muffler 1 Outlet, °C$^{(1)}$	165 (315-140)	165 (305-139)	165	160 (255-120)	160 (275-122)	160 (291-126)
Integrator, °C	161	167	164	148	149	154
Muffler 2 Inlet, °C$^{(1)}$	155 (303-135)	155 (298-140)	155	155 (251-120)	150 (271-120)	155 (285-126)
Muffler 2 Outlet, °C$^{(2)}$	153 (221-137)	164 (250-103)	159	150 (221-117)	146 (227-72)	150 (232-77)
Bumper Ambient, °C$^{(3)}$	31 (33-29)	31 (32-29)	31	24 (25-23)	25 (26-23)	27 (28-27)
Water Out, °C$^{(3)}$	71 (87-62)	69 (78-61)	70	56 (73-48)	57 (69-40)	62 (77-49)
Engine Air In, °C$^{(3)}$	47 (67-42)	42 (61-37)	45	36 (41-33)	37 (39-34)	42 (45-39)
Oil Sump, °C$^{(3)}$	94 (99-93)	94 (98-91)	94	94 (99-91)	93 (97-84)	93 (98-85)
Exhaust Man, mm Hg$^{(1)}$				25 (58-5.2)	25 (57-5.2)	26 (60.1-5.2)

(maximum-minimum)
(1) visual estimates of continuous trace
(2) readings taken every minute
(3) readings taken every two minutes

(4) fan located 2.87 m from bumper
(5) fan located 4.39 m from bumper
(6) fan located 5.92 m from bumper

substantially cooler. The average of 159°C is 31°C (56°F) less than the average at the engine. The range of temperatures is much narrower being 250-103°C (482-217°F). The maximum temperature at the end of the standard Mercedes exhaust system is half that of the exhaust from the engine indicating that the exhaust system, front muffler, rear muffler and connecting piping act as both a heat exchanger as well as a heat sink. The temperature excursions during acceleration, for example, were substantially lower at the tailpipe relative to the engine manifold.

An average exhaust manifold temperature over the UDDS of 190°C (374°F) must be considered "cool" and hardly sufficient to ignite carbon or even, possibly, to ignite partially burned fuel [illegible] oil products of combustion. The average outlet temperature at the tailpipe of 159°C (318°F) is, on the other hand, considered quite conducive to trapping of many aerosols such as sulfuric acid mist, partially burned fuel and oil etc.

The other exhaust temperatures shown on Table 5 were obtained at various points throughout the system. The system consisted of two 4.13 cm (1.625 inch) diameter pipes running parallel from the engine exhaust manifold flange to a "Y" junction 55.9 cm (22 inches) in length. From the "Y" to the front pipe flange, the distance was 35.6 cm (14 inches) and utilized a 4.76 cm (1.875 inch) diameter pipe. This is the "pipe flange listed in Table 5, a thermocouple located 92.27 cm (35.625 inches) from the engine manifold.

Another 141 cm (55.5 inches) of pipe is used to convey exhaust to the face of the front muffler,the first of two mufflers used in the stack system. The Muffler 1 inlet thermocouple was located 5.1 cm (2 inches) before the front muffler and the outlet thermocouple was located 5.1 cm (2 inches) beyond the front muffler outlet. These two temperature measuring locations are listed next on Table 5. The front muffler is of oval design with overall length of 27.3 cm (10.75 inches), width of 25.1 cm (9.875 inches) and thickness of 10.8 cm (4.25 inches).

Another 95.3 cm (37.5)inch length of exhaust tubing then connects to the rear muffler, a cylindrical shaped unit of 59.4 cm (23.375 inch) length, and 17.8 cm (7 inch) diameter. The rear inlet thermocouples were located 6.35 cm (2.5 inch) in front and 5.1 cm (2 inch) after the rear muffler. The final item of the system is a short straight tailpipe of 20.3 (8 inch) length and 5.1 cm (2 inch) diameter.

These intermediate exhaust temperatures range in average and max-min values between the exhaust manifold and the Muffler 2 outlet (at the tailpipe) in descending order as expected. The remaining four temperatures, bumper ambient, water out, engine air in, and oil sump are listed to document the vehicle/engine operating temperatures. Although the FTP temperature profiles were most important to this project, the other conditions and cycles were surveyed to obtain a broader data base. These measurements, made at 48.3 km/hr (30 mph), 96.5 km/hr (60 mph) and over the SET and FET driving cycles are summarized on Tables similar in format to Table 5 in Appendix B. They indicate that, as the average speed increased, the average exhaust temperatures likewise increased, as expected.

Further analysis of this data is deferred to another time since the most important data to this project is during the UDDS, Table 5. Such measurements over these cycles have rarely, if ever, been done in this way, especially with a diesel car and will likely have long range usefulness.

2. Chassis Dynamometer Simulation

Given the road temperature profiles in the form of a continuous recorder trace, as well as maximum, minimum and average data, the next step was to attempt the same extent of cooling in the chassis dynamometer laboratory. Originally it was thought that a large, variable flow fan, normally used for motorcycles, would be appropriate since the outlet velocity varied as the vehicle speed. 736 m^3/min (26000 CFM) The large, cooling fan, shown partially by the lower right photograph of Figure 7, is capable of 87 km/hr (54 mph) cooling air velocity from a $0.5m^2$ opening 71.1 m (28 inch) wide by 68.6 m (27 inch) high duct cross section.

Somewhat to our surprise, it was found that this fan would overcool the exhaust system and that the exhaust manifold temperature was disproportionately lower relative to the other exhaust system temperatures. Fairly decent agreements of the exhaust system temperatures were obtained only when the outlet of the large cooling blower was moved to 5.92 m (233 inches) from the front bumper. The extent of the agreement may be seen by comparing the average road to run 5. The large fan, even 6 meters from the car, still overcooled the engine, and front part of the exhaust system. The laboratory ambient was lower than the road ambient as indicated by the bumper thermocouple and this contributed some to the lower laboratory dynamometer temperature profile.

One interesting observation found early in the runs with the large blower was the effect of whether the hood was "up" or closed. When the hood was closed, the exhaust temperature at the engine manifold was noticeably affected. In order to simulate the road profiles, it was necessary to close the hood. This brought the engine temperatures and exhaust manifold temperature up and closer to the values measured on the road.

Appendix B contains the results of similar experiments and attempts to replicate the road temperature profiles in the dynamometer laboratory. Fairly good success was obtained, with hood down, using the large variable flow blower. It still had to be rolled back from the car some 4.39 meters (173 inches) or else the vehicle was overcooled. Please refer to Appendix B for the cruise tests at 48.3 km/hr (30 mph) and 96.5 km/hr (60 mph) and the transient SET and FET experimental data.

It soon became apparent that the large variable flow blower was overcooling the standard car, and it would have to be moved far from the car to simulate the road. It also became quite apparent that such a distance would not be possible on the chassis dynamometer planned for screening tests, one with ample floor space to the right of the vehicle for the exhaust and trap components and the dilution tunnel. Of real concern was whether the large single blower could properly cool the exhaust system when located to the right of the vehicle in the open laboratory instead of under the car. Most of the experimental hardware would not physically fit under the car, nor was this a requirement for experimentation.

As a result of these apparent conflicts, a new method of cooling the car was developed which consisted of the usual 150 m^3/min (5300 CFM) fan used for FTP testing of LD vehicles and five ducted blowers each capable of 42.5 m^3/min (1500 CFM). These blowers were fitted with 1.52 m (5 ft.) long 20.3 cm (8 inch) diameter sheet metal ducts that served to direct and locate the cooling flow where desired. Then, each fan motor was wired through a toggle switch on a small panel that could be manually switched "on" or "off". Thus, by carefully locating the fans and predetermining when the fan should be turned "on" or "off", a close simulation of the vehicle temperatures could be obtained. The under car stock muffler system temperatures were simulated by the six fans better than the single large blower. It did require another technician to watch the vehicle speed trace and turn the fans "on" and "off". In general, no fan was used between 0-8 km/hr (0-5 mph) and then the single FTP fan (150 m /min) would be turned on and left on until the speed dropped below 8 km/hr (5 mph). Other fans would be added as the speed increased and turned off as the speed decreased.

When a test of a candidate trap was made, the exhaust was directed out under the front passenger door and the device located on the lab floor. One or more of the smaller blowers would then be relocated to blow directly on the experimental test items. The switching procedure would be modified as necessary to again simulate the road FTP values. All screening tests involved replicate tests from a "hot" start. For convenience and since the traps all had a common feed exhaust point, the temperature simulation was based on the inlet to the usual front muffler, a point 2.32 m (89.5 inches) from the exhaust manifold. Prior to each new experimental series, the temperature profile was adjusted as necessary by altering fan location and their "on-off" sequencing. Using up to six fans and the manual control gave a flexible approach to road temperature simulation regardless of the type, size, or shape of trap encountered.

The photographs of Figure 3 show the arrangement of the five cooling fans. For the stock system, the arrangement in the left center and lower left photos was used; namely the FTP fan in the center (largest) with one blower directly below running under the radiator of the car. Then, one blower was located on each side terminating at the lower control arms and inside the left and right front tires. Then, two more blowers, one on each side of the car terminating just behind each tire and directed at an angle to force the air under the car were used.

For evaluation of traps during screening tests, the arrangement shown in the three right views of Figure 3 was used. The device was connected to the exhaust directed from under the right front floorboard. One or more blowers would then be moved, as shown, and directed on the test item.

B. Particulate Trap Screening Results

Approximately 9654 km (6000 mi) of laboratory operation were accumulated in the extensive screening tests made with the Mercedes 300D car. These tests did not commence until 6436 km (4000 mi) of street and highway operation had been accumulated to stabilize engine and exhaust system deposits. In all, a total of 42 "cold" start and 335 "hot" start 23 minute UDDS particulate runs were made of 48 traps or combinations. This total includes the periodic baseline runs made with the factory standard exhaust system.

In Part VII, it was found that the particulate emission rates for this Mercedes 300D test car are basically independent of the test cycle. Reference 28 lists particulate emission rates as follows:

1975 FTP	0.306 g/km
FTP cold	0.307 g/km
FTP hot	0.306 g/km
FET	0.242
SET	0.232

The higher speed and duty cycles of the FET and SET gave lower values than the FTP but not grossly lower. The FTP hot values are about average for the screening test.

Table 6 is a chronological summary listing of all the screening tests made as well as periodic baseline tests. This table is the basis for the discussion that follows and contains average g/km results for hot start, cold start (usually only one test), and the average system temperatures and pressures. In the case of the stock system, the "inlet" would be the inlet to the front muffler and the "outlet", the outlet of the rear muffler. For the trap or combination of trap items, the "inlet" would be the inlet to the first item in the system, normally at the 2.32 m (89.5 in) from the exhaust manifold flange.

The "outlet" was the outlet of the item (if a single item was evaluated) or the outlet of the final item if a series combination system was evaluated. Each item is described briefly and in terms consistent with the designation of Table 3. Also, the first item mentioned in a system was the first item through which exhaust was passed.

Appendix C is a detailed listing of each run of each test and is the basic reduced data from which the averages on Table 6 are obtained. The Appendix C tables, one for each item or system or baseline series, indicate the run-to-run repeatability as well as the extent to which, for a given series of tests, a trend might have occurred such as increase/decrease in pressure drop, efficiency, or temperature.

Listed at the bottom of each Appendix C table is a summary of the pressures and temperatures obtained during a series of steady-state engine/vehicle operations at idle, 0 km/hr, 16.1 km/hr (10 mph), 32.2 km/hr (20 mph), 48.3 km/hr (30 mph), 64.4 km/hr (40 mph), 80.4 km/hr (50 mph), and 96.5 km/hr (60 mph). This series was made at the conclusion of each test series and

TABLE 6. SUMMARY OF PARTICULATE REMOVAL EXPERIMENTS MERCEDES 300D

Date	System Description	Type Test	Average Particulate g/km	Avg. System Temp., °C		System Pressures, @ 80.5 kph, mm Hg		
				Inlet	Outlet	Inlet	Outlet	ΔP
1-23-76	Factory Stock	FTP$_c$	0.256	173	138			
	Mufflers	FTP$_h$	0.270	180	161	28.9	14.0	15.9
1-27-76	HCC Small Swirl	FTP$_c$	0.250	176	163			
		FTP$_h$	0.257	177	166	25.8	7.5	17.7
1-28-76	HCC Small Cyclone	FTP$_c$	0.242	186	156			
		FTP$_h$	0.208	179	151	198.0	27.1	170.2
1-28-76	HCC Large Cyclone	FTP$_h$	0.223	173	136	78.7	21.1	58.4
1-29-76	Texaco A-1R	FTP$_c$	0.097	163	157			
		FTP$_h$	0.090	160	152	47.3	5.0	43.3
1-30-76	HCC-137(1) Agg.	FTP$_c$	0.248	164	139			
		FTP$_h$	0.223	165	148	27.8	6.2	20.9
2-2-76	Ethyl Agg	FTP$_c$	0.301	165	154			
		FTP$_h$	0.259	165	152	15.1	8.0	6.9
2-4-76	Ethyl TAV$_s$	FTP$_c$	0.235	165	148			
		FTP$_h$	0.204	166	151	83.1	8.2	75.6
2-5-76	Texaco A-1R	FTP$_c$	0.176	160	157			
	with Exit Cavity	FTP$_h$	0.130	167	150	49.5	3.9	45.8
2-6-76	Bus Muffler, empty	FTP$_h$	0.250	160	126	3.4	3.2	0.5
2-9-76	Bus Muffler, full	FTP$_c$	0.246	162	87			
		FTP$_h$	0.252	163	123	5.6	5.6	0.9
2-10-76	Texaco A-1R &	FTP$_c$	0.168	167	135			
	Ethyl TAV$_s$	FTP$_h$	0.123	163	140	162.6	3.5	157.5
2-12-76	Texaco A-1R &	FTP$_c$	0.238	164	137			
	Small Swirl	FTP$_h$	0.176	162	144	76.2	5.0	73.7
2-13-76	Texaco A-1R &	FTP$_c$	0.198	169	127			
	Large Cyclone	FTP$_h$	0.170	168	139	137.2	20.0	119.4
2-16-76	HCC-137(1)& Ethyl	FTP$_c$	0.266	180	145			
	TAV$_s$	FTP$_h$	0.189	164	141	66.0	0.6	66.0
2-18-76	Factory Stock	FTP$_c$	0.307	168	147			
	Mufflers	FTP$_h$	0.263	163	144	23.3	10.5	11.6
2-20-76	Ethyl Agg & TAV$_s$	FTP$_h$	0.271	175	159	123.0	3.9	114.3
2-23-76	HCC-115	FTP$_c$	0.390	173	137			
		FTP$_h$	0.234	167	130	127.0	19.0	106.7
2-24-76	HCC-115A	FTP$_c$	0.228	174	130			
		FTP$_h$	0.211	170	129	147.3	15.9	137.1

TABLE 6. SUMMARY OF PARTICULATE REMOVAL EXPERIMENTS
MERCEDES 300D (Cont'd)

Date	System Description	Type Test	Average Particulate g/km	Avg. System Temp., °C		System Pressures, @ 80.5 kph, mm Hg		
				Inlet	Outlet	Inlet	Outlet	Δ P
2-25-76	HCC-125	FTP$_c$	0.297	164	122			
		FTP$_h$	0.246	162	131	34.0	4.3	29.3
2-26-76	Texaco A-IF Agg.	FTP$_c$	0.256	150	146			
		FTP$_h$	0.209	159	161	35.5	8.4	26.1
2-27-76	Texaco A-IF &	FTP$_c$	0.176	160	132			
	Texaco A-IR	FTP$_h$	0.099	162	146	84.0	2.2	82.2
3-02-76	HCC-137(1)Agg. &	FTP$_c$	0.350	175	136			
	Ethyl TAV$_s$	FTP$_h$	0.233	166	144	119.4	3.3	116.8
3-03-76	HCC-137 Agg.(2)	FTP$_c$	0.334	167	153			
		FTP$_h$	0.265	164	161	24.3	3.7	20.5
3-04-76	Ethyl TAV$_d$	FTPc	0.342	171	130			
		FTP$_h$	0.264	167	131	37.4	3.7	35.5
3-05-76	Factory Stock	FTP$_c$	0.418	175	154			
	Mufflers	FTP$_h$	0.292	169	148	23.4	10.8	13.4
3-08-76	Texaco A-IF &	FTP$_c$	0.258	169	134			
	Ethyl TAV$_s$	FTP$_h$	0.179	166	144	116.8	4.5	111.8
3-09-76	Texaco A-IF, A-IR,	FTP$_c$	0.113	172	107			
	Ethyl TAV$_s$	FTP$_h$	0.092	164	120	160.0	3.4	157.5
4-27-76	Factory Stock	FTP$_c$	0.260	186	165			
	Mufflers	FTP$_h$	0.313	179	156	23.0	9.9	12.1
4-29-76	Texaco Wire	FTP$_c$	0.248	146	151			
	Wool Only	FTP$_h$	0.201	148	153	26.5	4.7	21.5
5-03-76	Texaco A-1M Radial	FTP$_c$	0.376	179	165			
	Center Inlet	FTP$_h$	0.266	165	157	38.3	7.1	29.9
5-04-76	Texaco A-1M Radial	FTP$_c$	0.318	178	163			
	Outershell Inlet	FTP$_h$	0.305	166	155	50.4	5.2	48.6
5-05-76	HCC-137, w/	FTP$_c$	0.399	180	146			
	3/8" spheres	FTP$_h$	0.305	167	152	28.9	5.2	22.4
5-06-76	HCC-137, w/	FTP$_c$	0.341	172	138			
	3/16" spheres	FTP$_h$	0.302	166	153	28.6	5.2	23.0

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(1) Exhaust Flow radially outward

(2) Exhaust Flow radially inward

TABLE 6. SUMMARY OF PARTICULATE REMOVAL EXPERIMENTS MERCEDES 300D (Cont'd)

Date	System Description	Type Test	Average Particulate g/km	Avg. System Temp., °C		System Pressures, @ 80.5 kph, mm Hg		
				Inlet	Outlet	Inlet	Outlet	ΔP
5-06-76	HCC-Mini Swirl Separator	FTP$_h$	0.295	162	155	68.6	5.8	66.0
5-07-76	Factory Stock	FTP$_c$	0.351	180	158			
		FTP$_h$	0.327	172	154	22.4	9.5	12.7
5-10-76	Rear Muffler Shell	FTP$_c$	0.457	166	89			
	w/ 3/8" spheres	FTP$_h$	0.259	165	145	94.0	10.6	83.8
5-11-76	Rear Muffler Shell	FTP$_c$	0.217	170	83			
	w/ 3/16" spheres	FTP$_h$	0.232	168	143	175.2	10.8	165.1
5-12-76	Texaco A-IR,	FPT$_c$	0.372	165	131			
	HC Mini Swirl	FTP$_h$	0.186	166	145	111.8	5.6	109.2
5-13-76	Back Pack w/ fine Media	FTP$_h$	0.132	165	129	69.0	1.2	69.7
5-17-76	Back Pack	FTP$_c$	0.100	168	133			
	w/ med. Media	FTP$_h$	0.170	165	129	76.2	2.6	73.7
5-18-76	Back Pack	FTP$_c$	0.270	163	126			
	w/ coarse Media	FTP$_h$	0.222	161	136	22.4	2.8	19.6
5-20-76	Texaco A-IE	FTP$_c$	0.256	179	189			
	Axial Flow Cannister	FTP$_h$	0.247	180	180	106.7	10.3	96.5
5-21-76	Texaco A-IE &	FTP$_c$	0.158	180	133			
	Texaco A-IR	FTP$_h$	0.116	174	133	157.5	3.9	155.9
5-24-76	Texaco A-IE, Texaco A-IR & Ethyl TAV$_s$	FTP$_h$	0.116	186	110	200.7	0.4	200.7
5-26-76	Factory Stock Mufflers	FTP$_h$	0.326	167	149	19.2	9.0	10.3
6-09-76	Texaco A-IF,	FTP$_c$	0.182	213	149			
	Texaco A-IR & Ethyl TAV$_s$ (Pipe & A-IF Insulated)	FTP$_h$	0.165	220	177	188.0	3.0	185.0
6-10-76	Texaco A-IF, Texaco A-IR & Ethyl TAV$_s$ (Not Insulated)	FTP$_h$	0.165	169	130	182.9	2.4	180.5

serves to provide basic data not otherwise easily obtained during the transient UDDS operation.

The first experiment summarized on Table 6 was a 10 run variability test, one cold UDDS, and nine replications from a hot start using the standard, factory equipped exhaust system. The hot start run average of 0.270 g/km may be compared with the 0.311 g/km recorded earlier. Recall that the exhaust temperatures are somewhat different due to a difference in vehicle cooling.

Appendix Table C-1 lists the individual run results. The nine hot start results ranged from 0.262 to 0.282 g/km for the average of 0.270 g/km. The coefficient of variation was 3.2 percent based on a standard deviation of 0.009 g/km. The repeatability of the replicate runs is termed excellent and is indicative of the repeatability of replicate tests with the candidate trap systems.

Looking over the Table 6 summary for items that resulted in reduced particulate, it is interesting to note that the Texaco A-IR steel wool coated with Al_2O_3 did the best. The particulate rate of 0.090 g/km was an encouraging initial result for this approach. Of all the agglomerators, which this system was assumed to be, this item worked the best and continued to be the most effective.(38)

Of all the separators tried, the Ethyl TAV seemed to work the best along with the Houston Chemical small swirl. In any event, the separators were, by themselves, only partially successful, giving rates of 0.204 to 0.208 on replicate FTP hot 23 minute runs. The two top views of Figure 8 show the HCC small swirl disassembled and some of the particulate collected by the separator (right view). An interesting observation was made of the appearance of the swirl collected material. It was largely spherical in shape as if compacted inside of the swirl collector. The tiny balls rolled freely and evidently were made in spite of the stainless steel hardware cloth packing inside the collection chamber used to prevent re-entrainment of the collected particulate.

Another Houston Chemical swirl tube, of smaller size than that run earlier on January 27, 1976, was tried on May 6, 1976 and found to have little effect even at the higher backpressures and swirl rates. Inertial separation of the particulate is a very difficult problem and most efforts had little success. The hope is that when the best available separator is used in conjunction with an agglomerator, the particulates purged from the agglomerator will be heavier, bigger, or denser so that some inertial seperation can occur.

On May 12, 1976, the HCC mini swirl was connected to the outlet of the Texaco A-IR to see if this combination would be an improvement over the Texaco A-IR plus sigle Ethyl TAV_S. In both cases, May 12, 1976 and February 10, 1976, the removal of particulate was due to the A-IR, not the separator.

The two center views of Figure 8 show the swirl tube under test as a single component, left view, and in combination with the Texaco A-IR

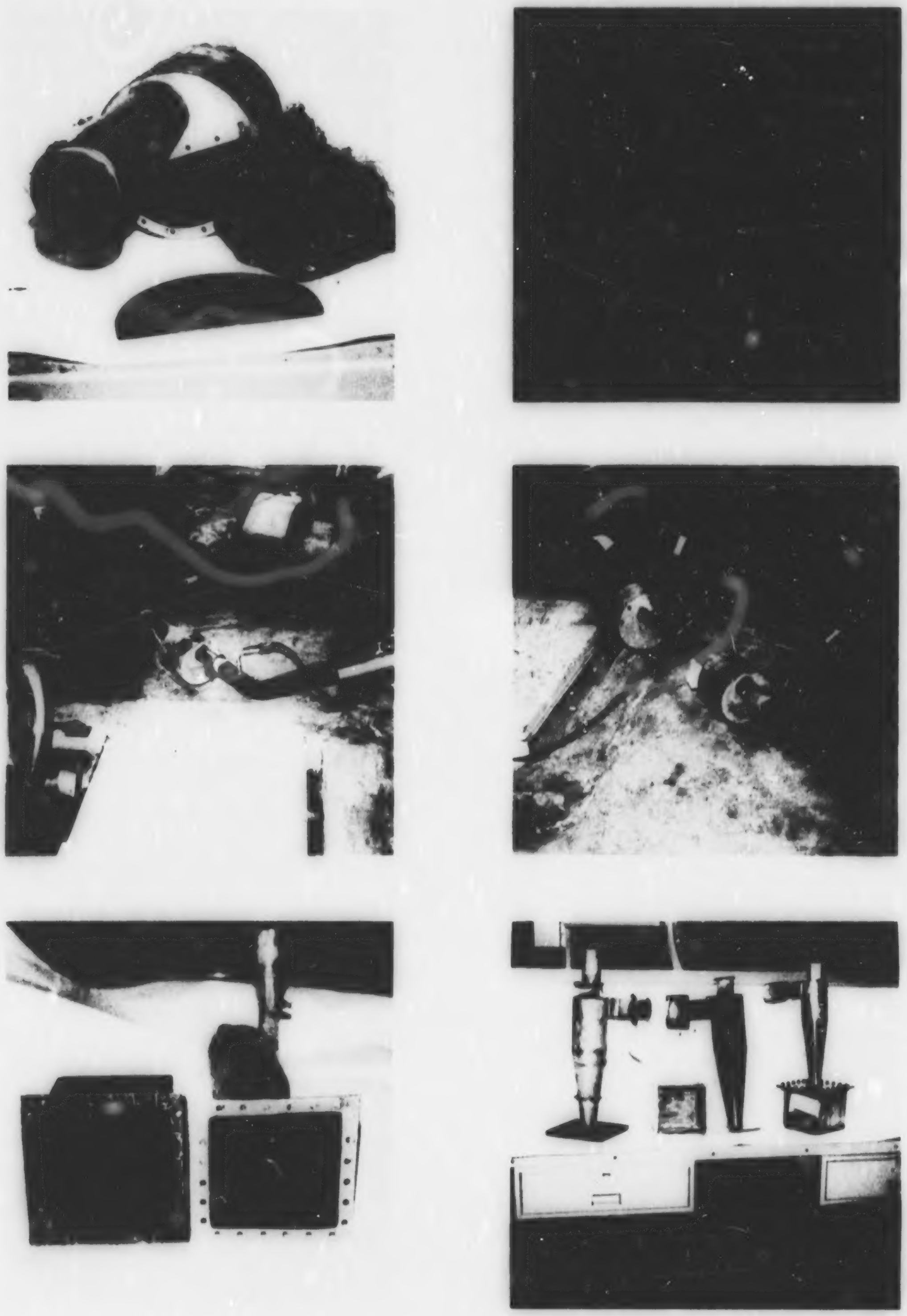

FIGURE 8. SWIRL TUBE AND CYCLONE SEPARATORS

with exit cavity. The two lower views are photographs of the various conventional cyclone separators evaluated. The left view shows the interior of the collection box. Their installation and test arrangement was shown earlier in Figure 3, upper and lower right views. Although the swirl tube separator showed some promise, the conventional cyclones were incapable of removing much particulate alone. This is indicated by the results listed on Table 6 for January 27 and 28, 1976.

Figure 9 shows various views of the muffler configurations prepared by SwRI and provided to Texaco for packing with steel wool similar to that of an industrial "Brillo pad", coating with alumina and then fired at 1000°F to achieve a permanent bond and develop the porous structure desired. The upper left view shows both the A-IR and A-IF units with end covers removed. The alumina is white when new.

The upper right view of Figure 9 shows the detail of the steel wool matrix before alumina coating. The 4/29/76 run was with a rear muffler packed with the steel wool used by Texaco but not coated with alumina. This experiment indicated that the wire only was able to remove about one-third of the particulate. This same size and shape rear muffler housing, filled with alumina coated steel wire by Texaco, was able to remove on the order of two-thirds of the particulate.

The right center view of Figure 9 shows the exit end of the A-IR after limited operation. The left center view shows the inlet face of the A-IR. The lower left view shows the two end plates, the entry cone and the exit, orginally a flat plate. The lower right view shows the exit cavity added to the A-IR to see if some particles might not drop out or collect. This was unsuccessful as found on 2/5/76 on Table 6. The small open volume, intended to allow agglomerates to settle out, should have improved performance and definitely not increased particulate. Apparently, the units collection efficiency changed because later tests on 2/10/76 likewise produced particulate above the 0.090 g/km found initially. Even with the TAV separator, performance was 0.123 g/km, still a respectable reduction from the stock rate of 0.279 g/km.

The upper left photo of Figure 10 shows the Ethyl agglomerator in combination with the Ethyl TAV. The agglomerator run on 2/2/76 as a single unit was not effective and neither was this combination, as may be seen on Table 6 on 2/20/76. The TAV did show some promise (see 2/4/76 data on Table 6) and it is shown in combination with other items such as the Texaco A-IF and A-IR in the upper right view, Texaco A-IR with cavity in center right photo and the HCC 137 agglomerator lower left view.

The use of the HCC 137 agglomerator plus the Ethyl TAV (2/16/76) resulted in 0.189 g/km, an average rate lower than either unit produced when used separately. The HCC 137 gave 0.223 g/km and TAV gave 0.204 g/km. In all these photographs, only one half of the TAV is used since it was found that the TAV single or TAV_S, on Table 6, was more effective than the dual configuration tested on 3/4/76. When both halves of the Ethyl TAV were run together, the g/km average value was 0.264 versus the 0.204 value for the single or one-half of the TAV run on 2/4/76. Although the baseline seems to trend higher with time and continued operation, it

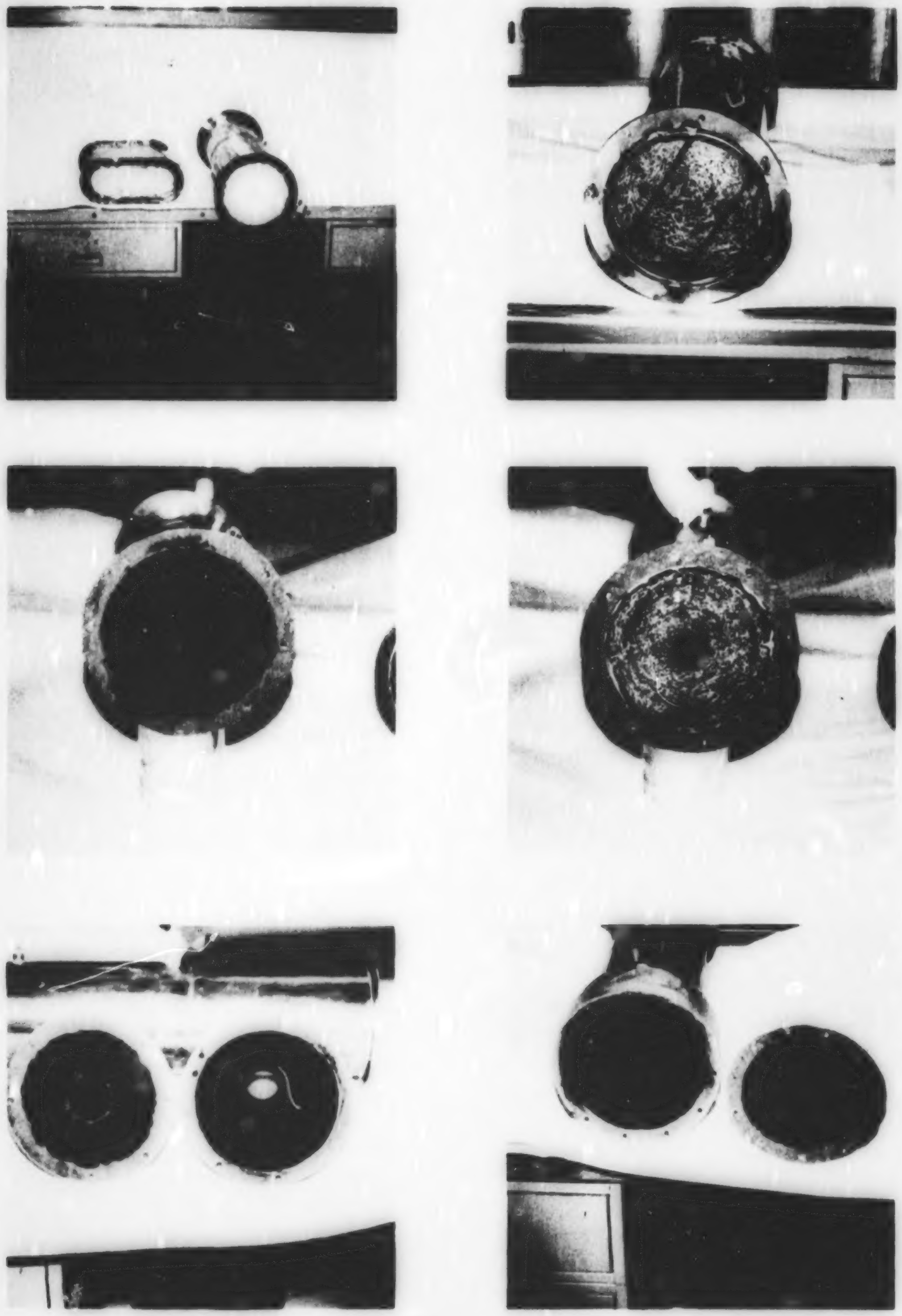

FIGURE 9. VARIOUS TEXACO ALUMINA COATED STEEL WOOL PARTICULATE TRAP CONFIGURATIONS A-IF AND A-IR

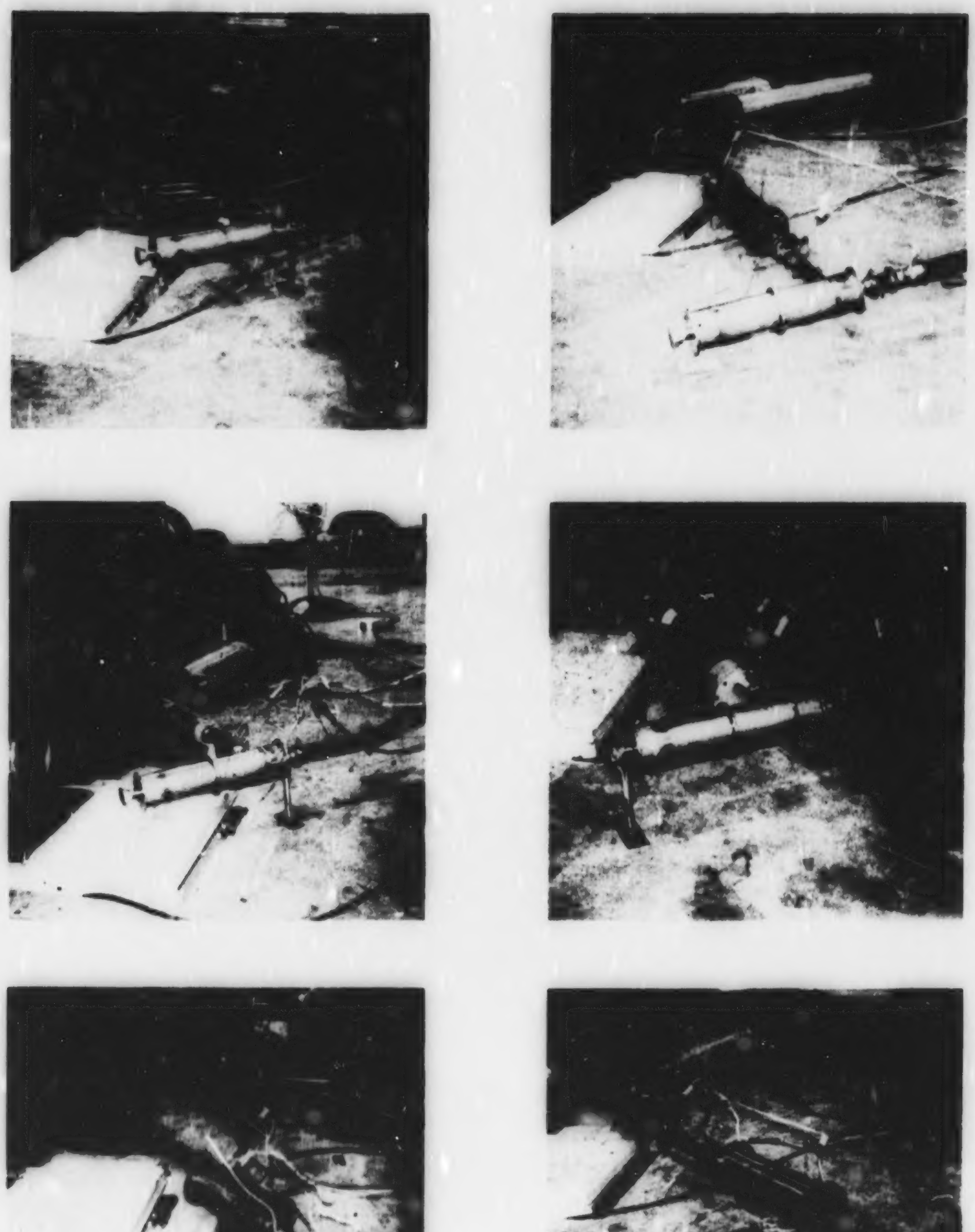

FIGURE 10. VARIOUS AGGLOMERATOR-SEPARATOR PARTICULATE TRAP COMBINATIONS

is clear that the single TAV is a better size for the 5 cylinder exhaust flow rate than is the dual. This was expected since the dual TAV can handle a large, high power to weight gasoline car.

The lower two photos show the Texaco A-IF (left view) and the A-IF plus A-IR (right photo) under test. These tests were made on 2/26/76 and 2/27/76 respectively and indicated the major reduction in particulate was due to the Texaco A-IR unit. The average particulate of 0.099 g/km can be compared to the factory mufflers tested on 2/18/76 and 3/5/76, which gave 0.263 and 0.292 g/km respectively. The particulate was reduced on the order of 36 percent of the average of these two baselines.

A number of other components that depended on trapping by use of a packed bed were evaluated. An empty rear muffler shell, A-IR was fitted with inlet and outlet screens and filled with alumina spheres of various diameters. This arrangement is shown in the upper left photo of Figure 11 with two sizes of alumina, a nominal 4.8 mm (3/16 inch) and 9.5 mm (3/8 inch) diameter.

The two sizes of Houston Chemical alumina spheres were tried in the relatively large rear muffler shell in which the exhaust was allowed to travel axially up through the packed bed. The results of these tests, on 5/10 and 5/11/76, were somewhat encouraging, but still had much less efficiency than the Texaco A-IR spherical shaped balls in the upper right photo. The center right photograph shows the large tank-like cylindrical muffler used in experiments with city buses. The muffler featured a packed bed containing a 27.2 kg (60 lb) charge of Al_2O_3 spheres of nominal 6.4 mm (0.25 inch) coated with a copper oxide catalyst.(12) The catalyst coated balls are poured into the muffler as shown in the left center photo.

The lower photographs of Figure 11 show the HCC 137 agglomerator disassembled (left view) and under test (right view). This was a very interesting and compact design (see Appendix A for pictorial schematic) in that the flow through the bed was radial instead of axial having possibilities for lower pressure drop as well as possibly longer life. Several sizes of alumina balls, packed into the annular chamber, were tried as well as operating the unit with radial inflow and with radial outflow through the packed bed. The original design for lead trapping was for the flow to pass through the agglomerating media radially inward, from the outer annulus to the inner cylinder. When run backwards, on 1/30/76, slightly more particulate was removed than when run as intended on 3/3/76. Although neither configuration gave an impressive removal of particulate, some insight on gas velocities and possible agglomeration mechanisms can be inferred. Higher face velocities apparently resulted in improved collection of the particulate.

Two experiments were made using the Houston Chemical 137 design where the size of alumina bead was varied. The tests on 5/5/76 were with a packed bed of nominal 3/8 inch spheres while the 5/6/76 experiments used nominal 3/16 inch spheres. These alumina balls supplied by Houston Chemical were a different porosity and apparently softer than the 1/4" spheres tried earlier. Neither experiment was considered successful.

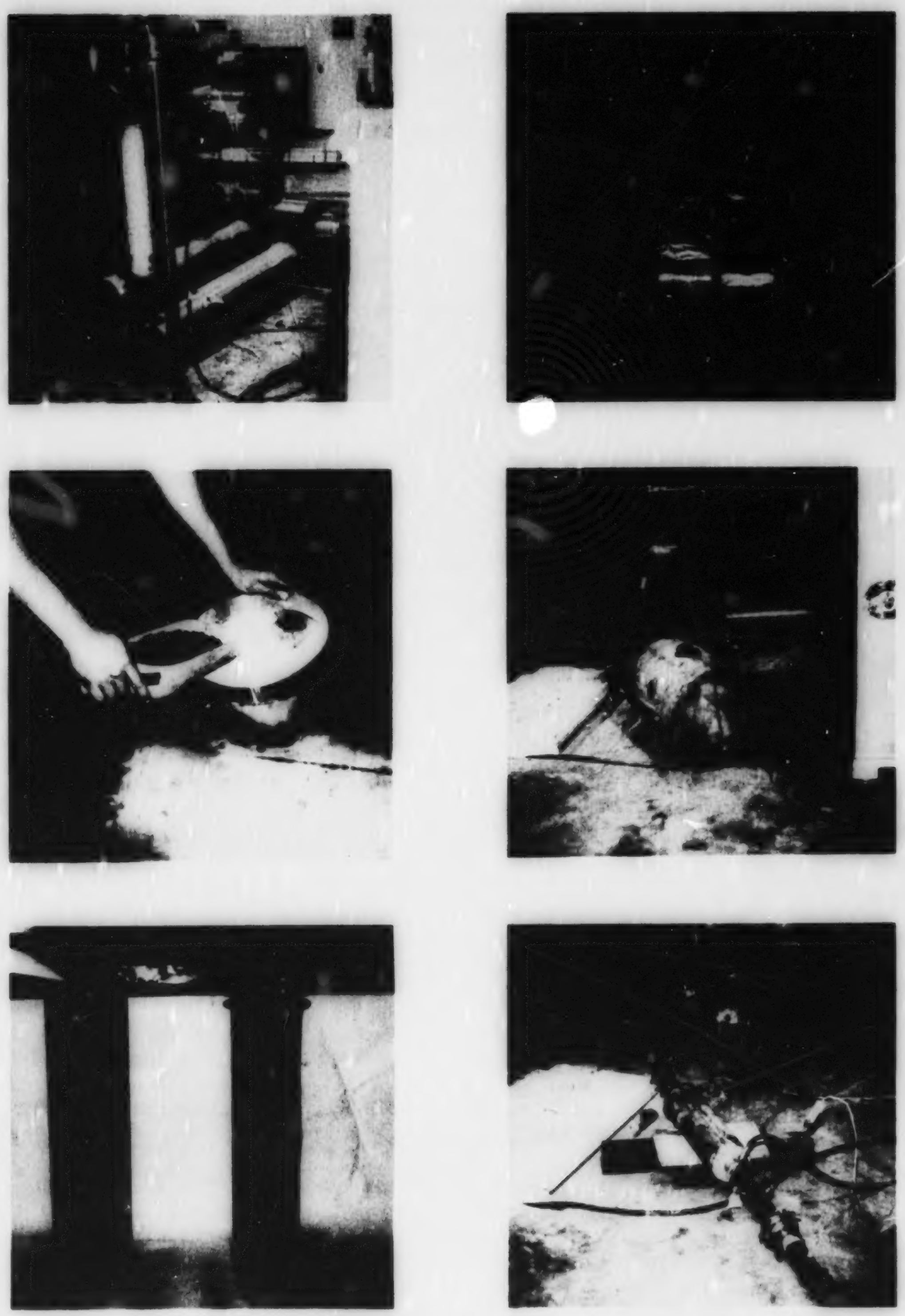

FIGURE 11. AGGLOMERATOR CONFIGURATIONS UTILIZING ALUMINA SPHERES OF VARIOUS SIZES

A variety of ingenious designs of integral agglomerator, separator/collector lead trap devices were evaluated. These were all Houston Chemical Company designs and are shown in test or partially disassembled on Figure 12 and in more detail by the pictorial schematics of Appendix A. The HCC 115, 115A, and 125 designs were evaluated with little success in terms of diesel particulate trapping efficiency. All designs had been demonstrated to be very effective in auto exhaust lead trapping and removal, however. All designs depended on agglomeration principally through the use of packed beds of alumina spheres with swirl or similar separators and wire mesh entrainment.

As the screening evaluation progressed, two additional configurations involving the Texaco alumina coatings were of interest. The upper left photograph of Figure 13 shows a design that is quite similar to the HCC-137 radial flow agglomerator. The annular element is inconel wire mesh coated with fired alumina furnished by Texaco.(39) This element was inserted into the larger cylindrical housing and designated Texaco A-IM. The idea was to run this element with exhaust entering the center of the element and flowing radially outward. Then the direction was reversed and the flow directed radially inward. The data on 5/3/76 and 5/4/76 indicated some particulate removal when the flow was radially outward. The improvement, however, was not enough to continue this design in the project. The hope was that the radial inflow would be effective so that the unit could be installed in the engine compartment at the engine exhaust manifold outlet.

The other SwRI design which hoped to capitalize on location near the engine to possibly use burn-off potential of available engine heat was a 10.2 cm (4 inch) diameter long radius weld 45 degree elbow of stainless steel with short straight sections on both ends. The packed system is shown in the center right photo of Figure 13 with the installation under the engine firewall shown in the left center photo. Tests of this unit, called A-IE on 5/20/76, were partially successful, but at a fairly high backpressure.

More tests were made of the Texaco A-IE unit, in combination with the Texaco A-IR,on 5/21/76 and then in combination with the Texaco A-IR and Ethyl TAV$_S$. The exhaust backpressures for the system climbed substantially to 200 mm Hg (about 8 inches Hg at 50 mph). The overriding influence in these, as in all previous tests with the Texaco A-IR, has been the Texaco A-IR. Further attempts to develop a pre-trap that used engine heat to oxidize fuel like particulate were discontinued.

The lower two photos of Figure 13 show the Houston Chemical backpack system for absolute filtration of the vehicle exhaust. Houston Chemical has widely used the "backpacks" for total and final filtration of gasoline car exhaust in conjunction with their studies of lead traps. The "backpack" can mount on the car trunk lid. The exhaust was filtered by about 0.93m^2 (10 ft^2) of glass fiber filter paper located on an accordian type stainless steel backing. The left view shows the box opened and the used fiberglass media in the accordian configuration. The backpack assembly is shown under test in the lower right view.

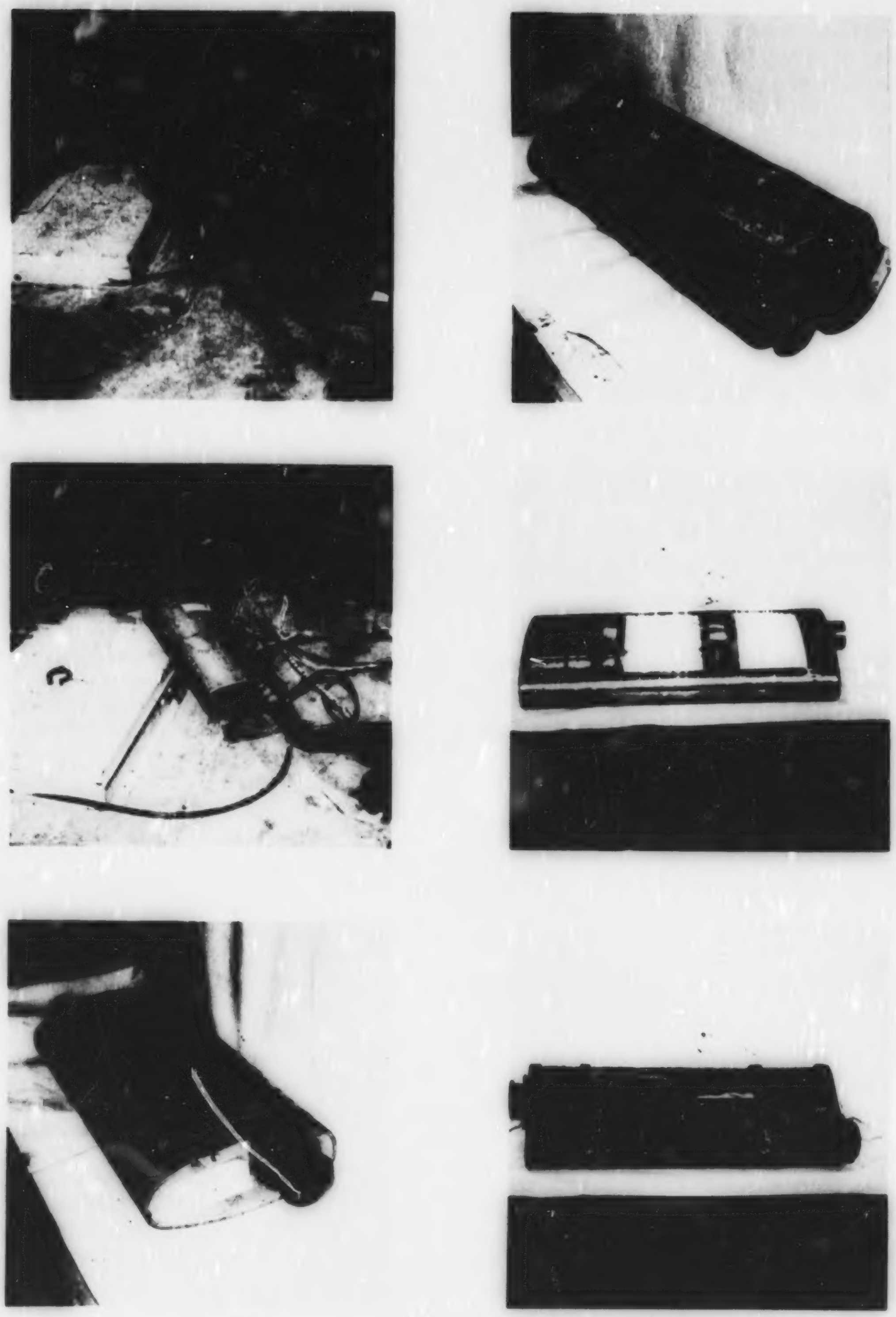

FIGURE 12. LEAD TRAP AGGLOMERATOR-SEPARATOR INTEGRAL DESIGNS

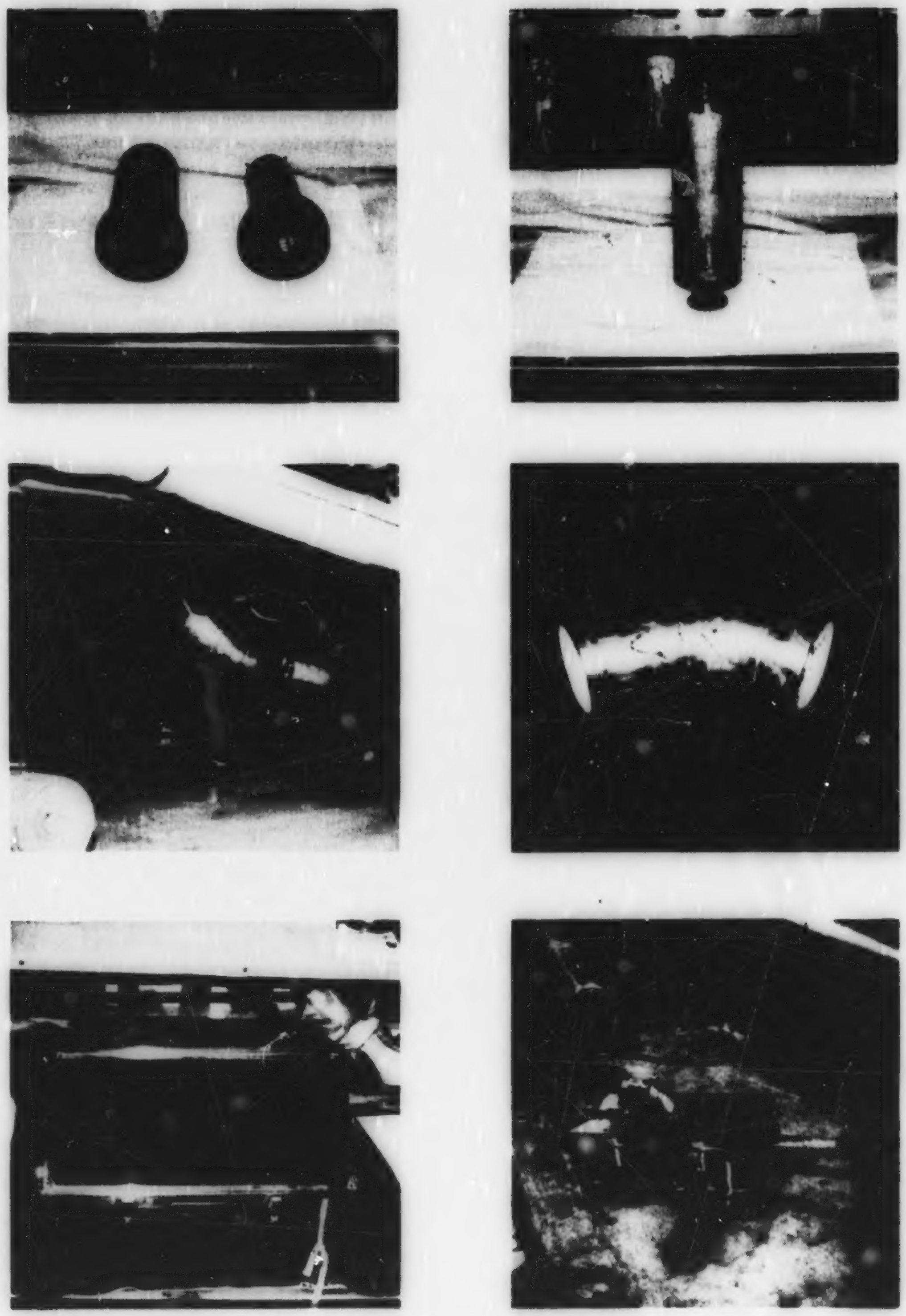

FIGURE 13. TEXACO ALUMINA COATED PARTICULATE TRAPS CONFIGURATIONS A-IE AND A-IM AND HCC BACKPACK FILTER BOX

On May 12, 13, and 17, three experiments were made with Houston Chemical "backpacks" equipped with a fine, medium and coarse fiberglass filter media furnished by Houston Chemical for trial. In the case of the runs with the fine and medium media, the filters were quite successful for a few runs in removing the particulate. Then, the system backpressure would rapidly increase and create a bypass through or around the media, usually around one edge or one corner. This would preclude the filter from functioning as desired and the test terminated. In the case of the coarse media, it was sufficiently coarse to apparently allow much of the particulate to pass directly through the filter. Further tests were discontinued with this approach.

Combining the Texaco A-IF with the Ethyl single TAV gave 0.170 g/km (3/8/76). An even lower value of 0.092 g/km was measured on 3/9/76 when the Texaco A-IF, A-IR and TAV_s were combined. In terms of the nearest baseline, this gave 32 percent of the factory standard exhaust system. The overriding factor in all experiments involving the Texaco A-IR is the Texaco A-IR. This relatively large cylinder of alumina coated steel wool dominated particulate removal experiments.

On May 28, 1976, a visit was made by the writer to Texaco, Beacon, New York and a full discussion of the results held with Mr. William Tierney and members of his staff. After reviewing the data and considering the backpressure of the A-IE and its apparent level of efficiency, it was decided that the A-IF would probably do as well or better than the A-IE. The A-IF was prepared earlier and retains the outside shape of the front resonator of the Mercedes 300D exhaust system.

As a final series of tests, the Texaco A-IF, A-IR and Ethyl TAV_s were run with and without the A-IF and front pipe insulated. Except for higher system backpressures with the system partially insulated, there was no effect noted on particulate removal. No indication of a temperature increase across A-IF was noted that might mean burn-off of trapped soft particulate (fuel oil vapors, etc.). Even though the TAV_s imposes a higher backpressure, the component test efficiences were better for the TAV_s than other separators such as the HCC mini swirl, making the Texaco A-IR and Ethyl TAV_s the preferred combination. The use of a separator, such as the TAV_s after the Texaco A-IR could be argued, since these experiments show the TAV to have only a minimal effect. Eventually, the A-IR will either plug or purge. If the unit plugs, the life will be very important. If the unit purges, then it is important to collect as much of the purge as possible. This is the reason for the separator.

C. Evaluation

Once the Texaco A-IF, A-IR and Ethyl TAV_s trap system had been identified as promising for diesel particulate removal, the next step was to perform a series of experiments to evaluate its effect on other emissions of interest, fuel economy, noise and performance. For purposes of discussion, each category is described separately.

1. Particulate and Sulfate

Duplicate glass and Fluoropore 47 mm filter samples were obtained by the following sequence, using the single EPA cooling fan in accordance with the Federal Register.

FTP 23 minute cold start
10 min soak
FTP 23 minute hot start
10 minute soak
SET 23 minute
10 minute soak
FET 12 minute

The above sequence was performed several times to establish the effect of the filter system on sulfate and particulate and then repeated with the factory exhaust system. To make the results as comparable as possible, the baseline runs were made at the same backpressure at 80.5 km/hr (50 mph) as the trap system by adjusting a gate valve in the exhaust pipe between the vehicle and the dilution tunnel. A nominal 178 mm (7 in) of mercury was imposed by the trap system.

Table 7 is a summary of the pertinent particulate and sulfate emission rates in grams (particulate) and milligram (sulfate) per kilometer of test operation. Listed first are the average particulate and sulfate emission rates from the previous evaluation of this car in factory stock configuration. These initial evaluations were made over eight months earlier and reported in the Part VII final report.(28) These initial tests were made at the normal exhaust backpressure.

Listed next on Table 7 are the most important average data from that contained in Appendix D. Appendix D includes listings for each trial in terms of mass per unit of time, distance and mass of fuel consumed. Note the generally good agreement between both sets of factory standard exhaust systems, even though the tests were made at grossly different exhaust system backpressure and substantial time and vehicle operation ensued in the interim.

Of the three particulate rates on Table 7, the most important is that by the 47 mm glass filter, the first column of data. When the trap system was run against the standard exhaust system, set to 178 mm Hg (7 in Hg) at 80.5 km/hr (50 mph) and the single standard EPA cooling fan used, the reduction in particulate ranged from 32.5 to 41.8 percent depending on test cycle.

These values indicate substantial reductions in particulate but are not as large as those found during the screening tests reported earlier where 60 percent reduction was fairly common during the hot start FTP. The reasons for this apparent fall-off in effectiveness are not understood and their investigations beyond the scope of this project. There are, however, some possible effects that may explain part of the loss.

TABLE 7. PARTICULATE AND SULFATE RATE SUMMARY

Test	Exhaust System	Particulate g/km			Sulfate
		Glass	Fluoropore	8 x 10	mg/km
1975 FTP	Factory Exhaust(1)	0.306	0.272	0.321	9.15
	Factory Exhaust(2)	0.295	0.293	0.286	8.440
	A-IF, A-IR, TAV_s	0.198	0.155	0.188	1.413
	Net Reduction(3)	0.097	0.138	0.098	7.027
	Percent Reduction(4)	32.9	47.1	34.3	83.3
FTP_c	Factory Exhaust	0.319	0.266	0.349	10.09
	Factory Exhaust	0.332	0.332	0.316	9.789
	A-IF, A-IR, TAV_s	0.220	0.167	0.230	1.863
	Net Reduction	0.112	0.163	0.086	7.926
	Percent Reduction	33.7	49.1	27.2	81.0
FTP_h	Factory Exhaust	0.311	0.277	0.300	8.44
	Factory Exhaust	0.268	0.264	0.264	7.423
	A-IF, A-IR, TAV_s	0.181	0.144	0.154	1.074
	Reduction	0.087	0.120	0.110	6.349
	Percent Reduction	32.5	45.4	41.7	85.5
SET	Factory Exhaust	0.232	0.220	0.238	10.27
	Factory Exhaust	0.204	0.219	0.209	11.700
	A-IF, A-IR, TAV_s	0.137	0.117	0.120	0.855
	Reduction	0.067	0.102	0.089	10.845
	Percent Reduction	32.8	46.6	42.6	92.7
FET	Factory Exhaust	0.242	0.221	0.258	11.22
	Factory Exhaust	0.201	0.199	0.188	9.669
	A-IF, A-IR, TAV_s	0.117	0.097	0.104	0.641
	Reduction	0.084	0.102	0.084	9.028
	Percent Reduction	41.8	51.3	44.7	93.4

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(1) from Part VII Final Report,(28) original tests, factory exhaust

(2) backpressure adjusted to 178 mm Hg (7 in Hg) at 80.1 km/hr

(3) net reduction is factory exhaust at increased backpressure minus trap system

(4) percent reduction = $\frac{\text{net}}{\text{factory}} \times 100\%$

Figure 14 is a chronological plot of every hot start evaluation of the Texaco A-IR, the unit in the system that has been responsible for the particulate removal as well as the A-IF and A-IE. Also plotted are the hot start factory standard baseline tests made throughout the screening test period. The difference between the factory stock, top graph, and the experiments with the steel wool coated with alumina (Texaco), bottom graph, is the reduction. On several occasions, notably February 5 and 10, 1976; March 9, 1976; and May 21 and 24, 1976, the A-IR plus A-IF or A-IE and/or TAV_s resulted in significantly lower particulate than the baseline which was on a slight upward trend with time (engine/vehicle operation).

For example, the most recent screening test, the back-to-back evaluation of June 14-25, 1976, gave a 65 percent reduction, from 0.327 g/km on May 7 and May 26 baselines to 0.116 g/km on May 24, 1976. These tests were with the trap system external to the car and with several cooling fans to simulate road temperature profiles.

The next set of experiments was made with the trap system located under the car in an insulated (from manifold to the exit of the A-IF unit) and normal uninsulated condition. Several fans were used but the profiles not exactly replicated since this series was to evaluate the importance of the insulation which evidently was not important.

The trap particulate rate, for some unknown reason, jumped from 0.116 g/km on May 21-24, 1976 to 0.165 g/km on June 9-10, 1976. When the single EPA cooling fan was used with the under-car mounted trap system, the particulate rate increased again to 0.181 g/km. Could the cooling fan and the mounting of the system under the car be responsible for this increase?

Simultaneous with the increases in particulate rate with the trap, ostensibly due to cooling and mounting, the baseline with the factory exhaust decreased from 0.327 g/km on May 7-26, 1976 to 0.268 g/km on June 23-25, 1976. Two changes were made; namely, the use of the single EPA cooling fan and the artificial increase in exhaust backpressure to 178 mm Hg (7 in Hg) at 80.5 km/hr (50 mph). Both possibly might affect particulate rates although the extent to which either parameter would reduce particulate emissions is unknown.

Thus, the reduced effectiveness of the particulate trap may be viewed in terms of the history and circumstances of the screening versus evaluative type tests. It is hard to attribute both the reduced particulate from the factory system and the increased particulate from the trap system to the same change in cooling; and, without more data on the effect of backpressure on the formation of particulate, this engine parameter remains mainly an "interesting observation".

Returning to Table 7, it is interesting to note the quite consistent g/km rates of particulate by the 47 mm Fluoropore filters as compared to the 47 mm glass. The slightly greater effectiveness indicated by the Fluoropore filters can be attributed to the consistently lower particulate rates by the Fluoropore versus fiberglass collecting media. Although the particulate rates were quite comparable by all three filters, 47 mm glass, 8 x 10 glass and 47 mm Fluoropore, with the standard factory exhaust system,

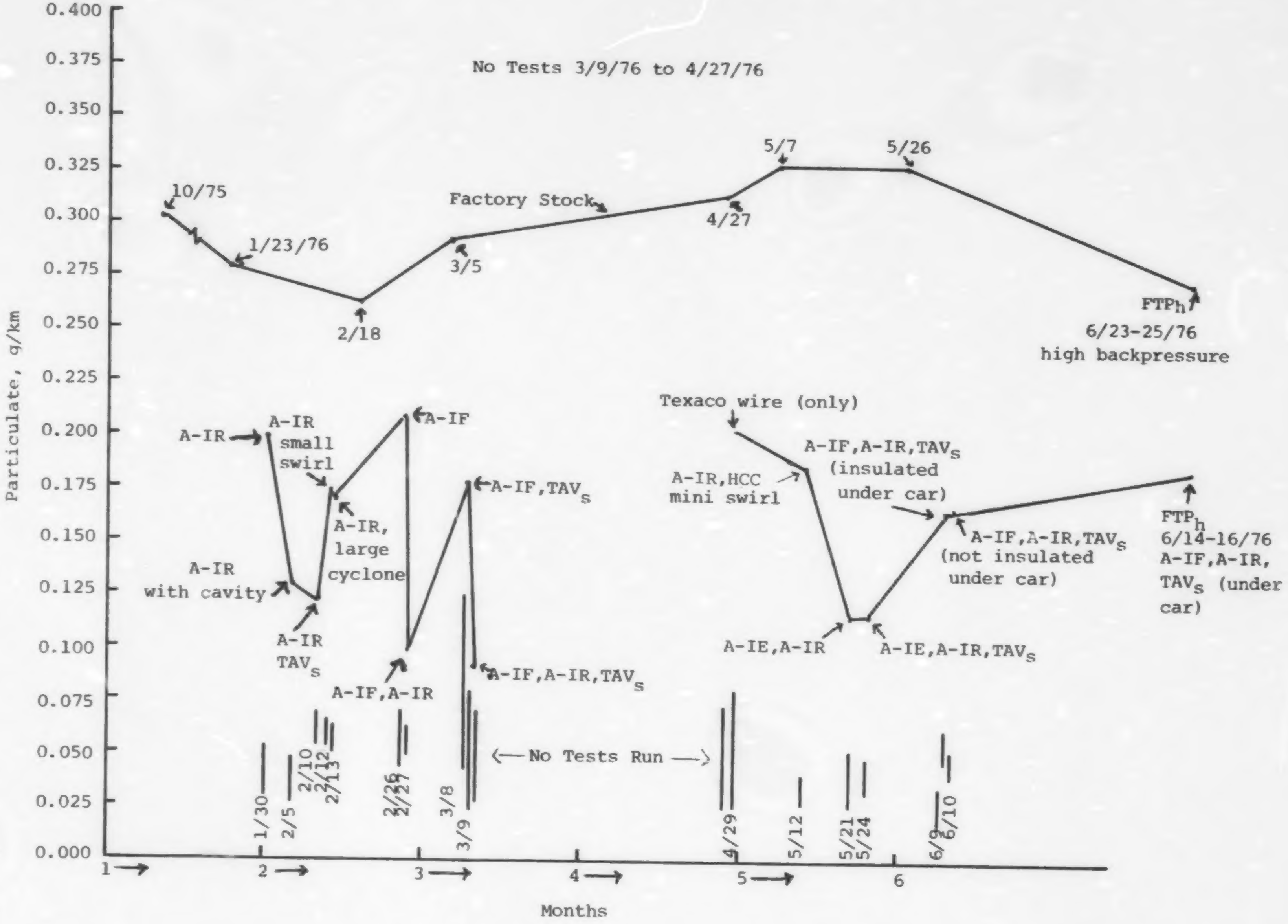

FIGURE 14. BASELINE AND TEXACO PACKED TRAP PARTICULATE EXPERIMENTAL RESULTS SCREENING AND EVALUATION - HOT FTP TESTS

this was not the case with the Fluoropore. Why the Fluoropore collected less (or fiberglass collected more) is unknown. Please note that the 8 x 10 fiberglass samples resulted in essentially equivalent particulate rates though performed on a separate test sequence with a different sample probe system.

Finally, Table 7 shows the most dramatic reduction in exhaust sulfuric acid mist, sulfate, ever encountered at SwRI. The system, probably the Texaco fired alumina, removed on the order of 80 to 90 percent of the sulfate. Stated in a different way, the particulate trap system resulted in about 6 to 20 percent of the sulfate emission of the factory system. Apparently, the Texaco A-IR and A-IF units act as substantial traps for removal and temporary storage of sulfuric acid mist. Just how long the sulfuric acid will remain in the traps before purge is largely unknown. It is interesting to see that the sulfate represents 2.9, 2.7, 5 and 4.7 percent of the total particulate for the FTP_c, FTP_h, SET and FET tests, respectively, based on the factory exhaust system. This agrees very well with the earlier data reported on this and four other LD diesel cars.(28)

2. Transient Cycle Smoke Emissions

The natural or common tendency is to relate visible smoke to particulate, or attempt to do so. Tables 8, 9, and 10 are readings of smoke opacity by the EPA end-of-stack smokemeter which monitored the smoke discharge of the vehicle continuously during the 1975 FTP, SET and FET driving cycles. Listed first on all three tables are the average results of a similar series of experiments with the factory stock system at normal backpressure. These readings were taken ten months earlier and reported in Part VII final report.(28) The agreement is quite good, as was mentioned earlier for particulates and sulfates, between the factory system initially evaluated in October 1975 and the retest at increased backpressure in August 1976. It is difficult to find any consistent difference that might be attributable to the increased backpressure or the time-mileage change between tests.

The factory stock exhaust smoke was run once for back-to-back comparison with the trap system. The backpressure was adjusted to match the trap system and only the one EPA cooling fan used.

From Table 8, the 1975 FTP results, it is apparent that the trap system nearly eliminated the very brief but noticeable cold start puff of smoke. The smoke peak at hot start was also reduced, but not as much. The particulate trap resulted in slightly lower smoke during all idle periods even though idle smoke from the factory standard Mercedes 300D is on the order of 4 to 6 percent opacity. Acceleration peaks are quite common to diesels, but the trap seemed largely ineffective under this type of condition.

On one occasion (one run) the trap system apparently purged during an accel, resulting in a peak of three times the factory system opacity. This occurred during the accel to 90.1 km/hr (56 mph) in the hot start (505 sec) portion of the test. Except for these few instances, the ability of the trap to remove particulate would go unnoticed since the effect on visible emissions is a minor one. Figures 15 and 16 are reproductions of the smoke

TABLE 8. EPA SMOKEMETER READINGS DURING 1975 FTP MERCEDES 300D WITH/WITHOUT PARTICULATE TRAP SYSTEM

	Smoke Readings from Trace, % Opacity					
			A-IF, A-IR, and TAV$_S$ Particulate Trap System			
Smoke Condition	Factory 10/1975(1)	Factory 8/23/76(2)	Run 1	Run 2	Avg.	Difference 8/23/76 - Trap Avg.
Cold Start, Peak %	36.8	38.0	5.3	7.0	6.2	31.8
Cold Idle, Average % (after start)	6.2	6.0	4.0	4.7	4.4	1.6
First Accel, Peak % (after cold idle)	21.4	12.0	10.5	11.0	10.8	1.2
Idle at 125 sec, Average %	5.1	4.5	2.9	3.3	3.1	1.4
Accel at 164 sec, Peak % to 90.1 km/hr (56 mph)	20.7	20.5	20.0	18.0	19.0	1.5
Hot Start, Peak %	29.3	18.5	9.7	8.3	9.0	9.5
Hot Idle, Average % (after start)	4.5	4.5	2.0	2.8	2.4	2.1
First Accel, Peak % (after hot idle)	6.5	8.0	5.0	5.6	5.3	2.7
Idle at 125 sec, Average % (during final 505 sec)	3.3	5.3	2.5	2.8	2.7	2.6
Accel at 164 sec Peak % to 90.1 km/hr (56 mph) (during final 505 sec)	8.7	7.5	23.2	12.0	17.6	-10.1

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(1) from Part VII Final Report, runs made in October 1975.(28)

(2) exhaust backpressure adjusted to 178 mm Hg (7 in Hg) at 80.5 km/hr (50 mph)

TABLE 9. EPA SMOKEMETER READINGS DURING SET-7 MERCEDES 300D WITH/WITHOUT PARTICULATE TRAP SYSTEM

Smoke Condition	Smoke Readings from Trace, % Opacity Factory 10/1975[1]	Factory 8/23/76[2]	A-IF, A-IR, and TAV_S Particulate Trap System Run 1	Run 2	Avg.	Difference 8/23/76 - Trap Avg.
Hot Start, Peak %	31.5	14.0	9.8	8.3	9.1	4.9
Idle, Average % (after start)	4.5	4.8	3.5	3.0	3.3	1.5
First Accel, Peak % to 26.1 km/hr	6.5	8.0	4.5	4.7	4.6	3.4
Accel at 189 sec, Peak % from 16.1 km/hr to 90.9 km/hr	5.5	3.0	3.8	2.0	2.9	0.1
Accel at 527 sec, Peak % from 0 km/hr to 57.1 km/hr	9.8	8.0	20.0	24.7	22.4	-14.4
Accel at 638 sec, Peak % from 15.6 km/hr to 91.7 km/hr	4.0	4.5	15.0	11.0	13.0	-8.5
Accel at 944 sec, Peak % from 22.5 km/hr to 90.9 km/hr	4.5	4.0	1.5	1.5	1.5	2.5

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[1] from Part VII Final Report, runs made in October 1975.[28]

[2] exhaust backpressure adjusted to 178 mm Hg (7 in Hg) at 80.5 km/hr (50 mph).

TABLE 10. EPA SMOKEMETER READINGS DURING FET MERCEDES 300D WITH/WITHOUT PARTICULATE TRAP SYSTEM

	Smoke Readings From Trace, % Opacity					
		Factory	Particulate Trap System			Difference
Smoke Condition	10/1975(1)	8/23/76	Run 1	Run 2	Average	8/23/76-Trap Avg.
Hot Start, Peak %	26.0	20.0	9.4	6.9	8.2	11.8
Idle, Avg. % (after start)	3.5	5.3	3.5	3.8	3.7	1.6
1st Accel, Peak % to 79.6 km/hr	8.0	12.0	4.0	4.8	4.4	7.6
Accel, Peak % to 94.9 km/hr	4.5	6.0	6.0	4.4	5.2	0.8

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(1) from Part VII Final Report, runs made in October 1975.(28)

(2) exhaust backpressure adjusted to 178 mm Hg (7 in Hg) at 80.5 km/hr (50 mph)

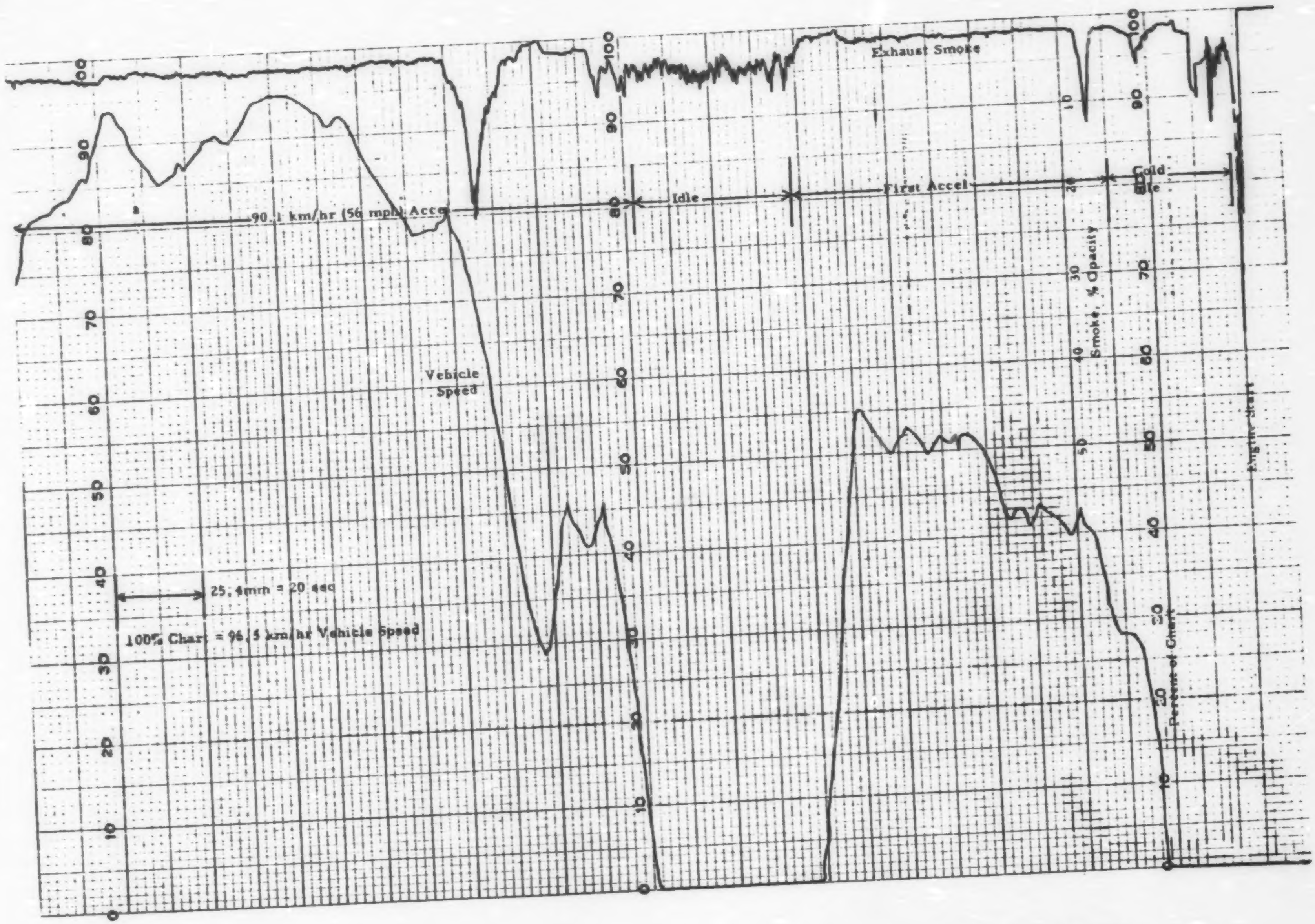

FIGURE 15. TYPICAL MERCEDES 300D "COLD START" SMOKE TRACE, FACTORY MUFFLER SYSTEM

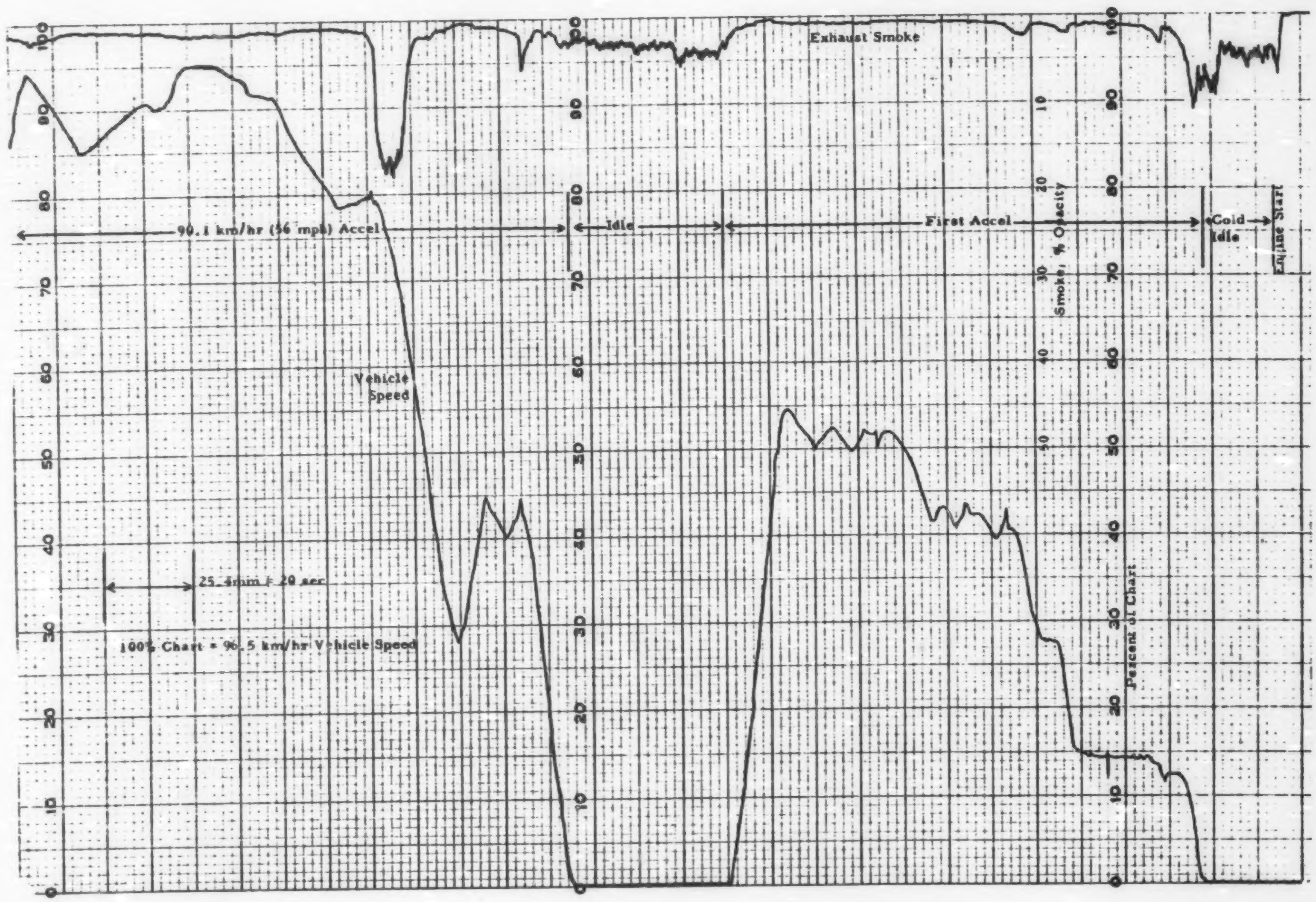

FIGURE 16. TYPICAL MERCEDES 300D "COLD START" SMOKE TRACE A-IF, A-IR, TAV$_S$ TRAP SYSTEM

trace and by comparing one to the other, some idea of the smoke reduction possibilities may be estimated.

On Figure 16, the trap system resulted in a wider peak during the accel to 90.1 km/hr (56 mph) than when the factory system was installed (Figure 15). Possibly the trap system was purging and the peak represents the purge of material, particulate previously stored in the trap.

Figures 17 and 18 are typical traces taken from the 420 to 710 second portion of the SET cycle--the area where two accelerations from rest are made, the second one at about 530 seconds has a fairly rapid rate of acceleration. Note the rather high peak recorded with the trap system during the acceleration indicating a brief but noticeable purge.

The remainder of the time, the smoke trace is generally lower than the factory system, Figure 17. Table 9 lists more details for specific comparison. Both trials showed over double the smoke peak opacity during the rapid accel. Otherwise the ratings are not particularly different, or indicate a different conclusion than the one given earlier.

The FET, described on Table 10, is depicted by the engine start, acceleration sequence shown in Figures 19 and 20. The lower smoke shown in Figure 20 relative to Figure 19, attests to the performance of the trap system. An interesting reversal in accel smoke was the apparent reduction in smoke opacity by the trap system during the accel to 29.6 km/hr. Although particulate is not necessarily smoke, smoke seems related in many instances to particulate by a general comparison of the smoke ratings and the particulate data of Table 7.

In summary, the smoke tests indicate the particulate trap system offers some advantages in reducing visible emissions, taken as above 3 to 4 percent opacity by the EPA smokemeter. This occurred chiefly during engine start and idle. The trap system failed to consistently reduce visible emissions during acceleration of the vehicle. In fact, on two occasions, the peaks were higher and/or wider than with the factory system indicating some purge of the unit may have been happening.

3. Transient Cycle Gaseous Emissions

Table 11 lists the average of the replicate gaseous emission and fuel economy test results for the Mercedes 300D with and without the particulate trap system installed. Also listed are the average values measured during the evaluation of the vehicle during the Part VII initial testing of the Mercedes 300D in November of 1975.

Comparing the factory system average results with the Part VII results, it is evident that there was excellent agreement between CO, NO_x, and fuel consumption. HC, during the 1975 FTP, was about double that of the Part VII results, 0.19 g/km versus 0.10 g/km. HC emissions during the SET and FET were the same as Part VII.

Comparing the three run average trap system results to the two run factory results indicates no noteworthy difference in CO or NO_x. HC were

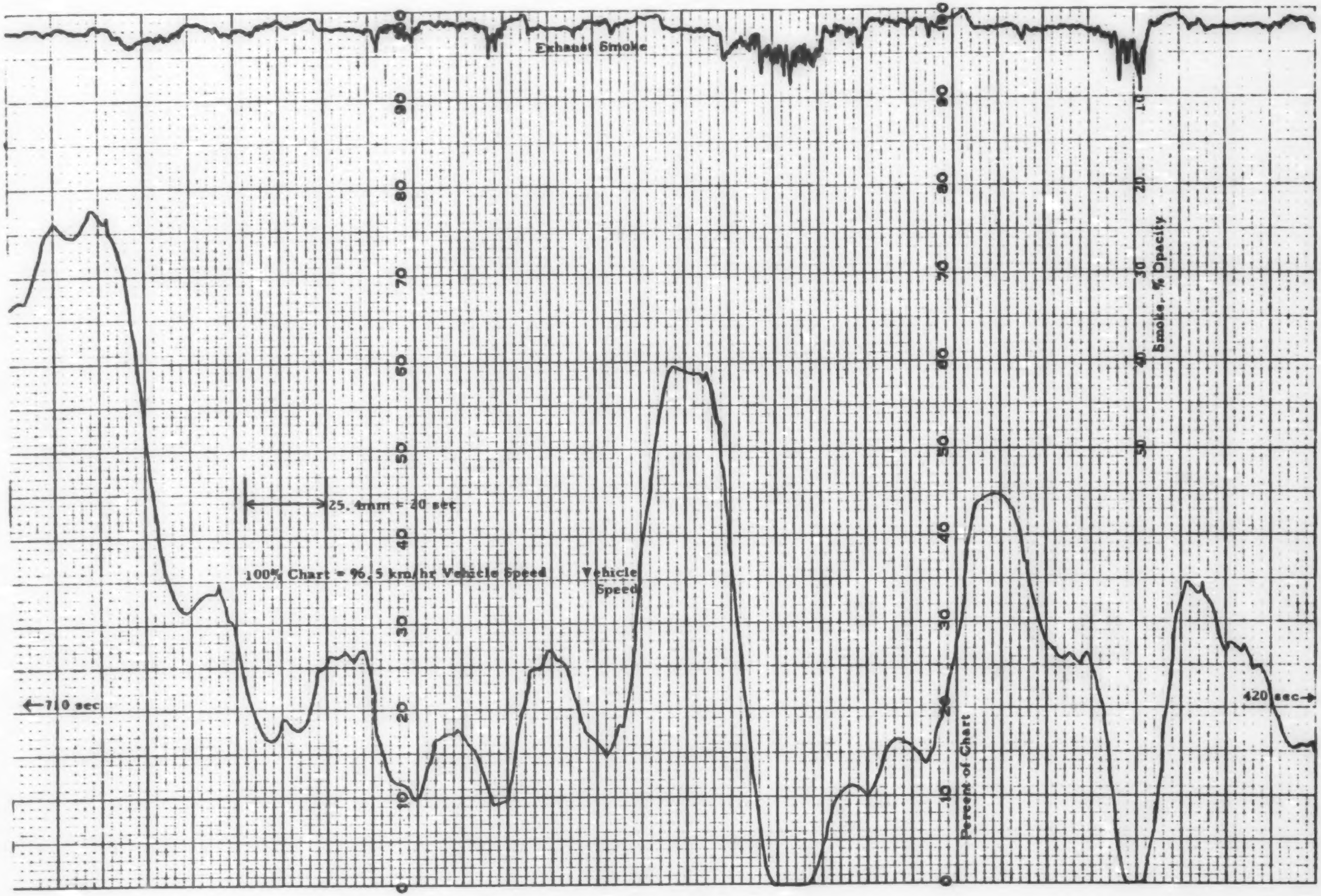

FIGURE 17. TYPICAL MERCEDES 300D SET-7 SMOKE TRACE, FACTORY MUFFLER SYSTEM

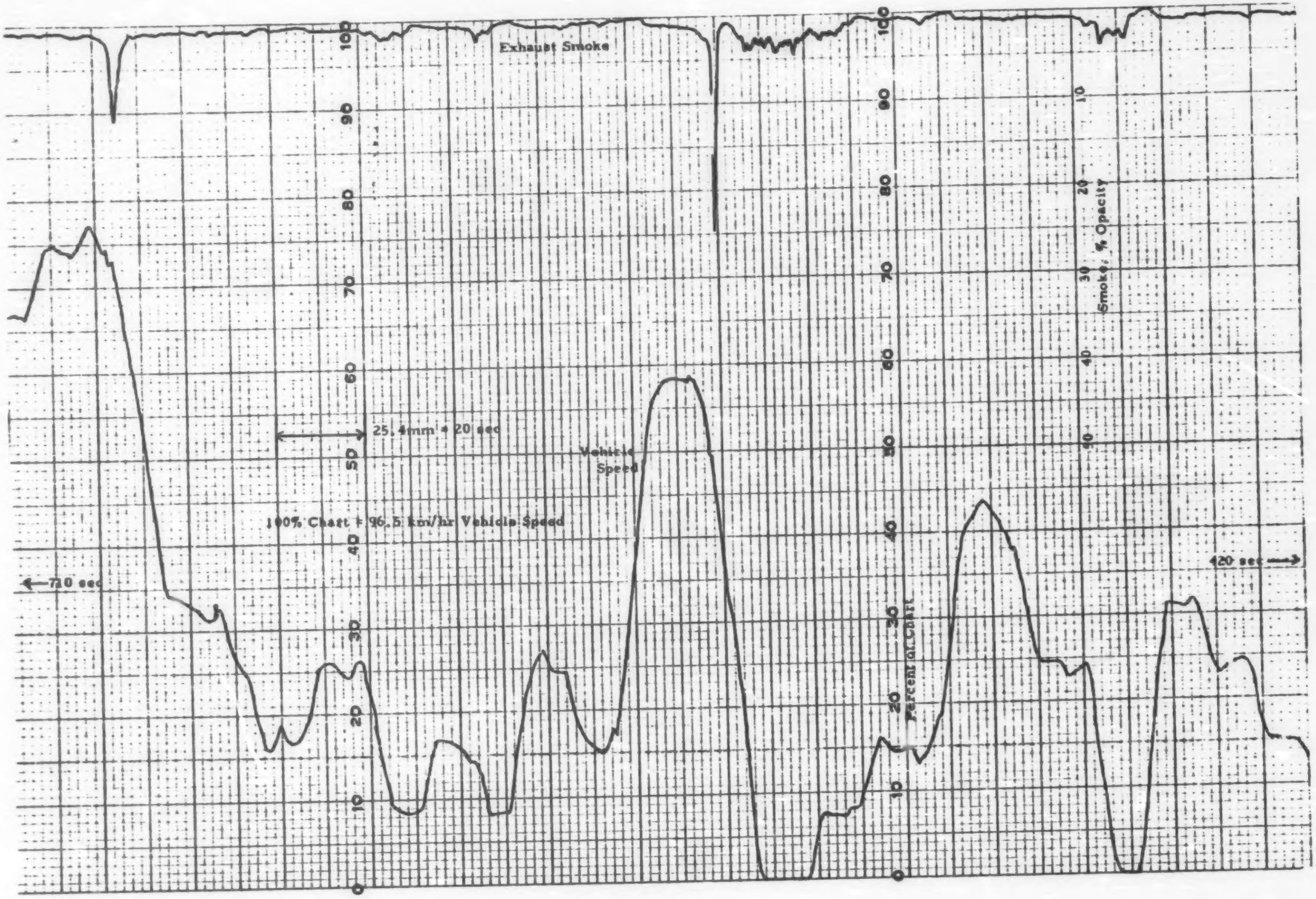

FIGURE 18. TYPICAL MERCEDES 300D SET-7 SMOKE TRACE, A-IF, A-IR, TAV$_S$ TRAP SYSTEM

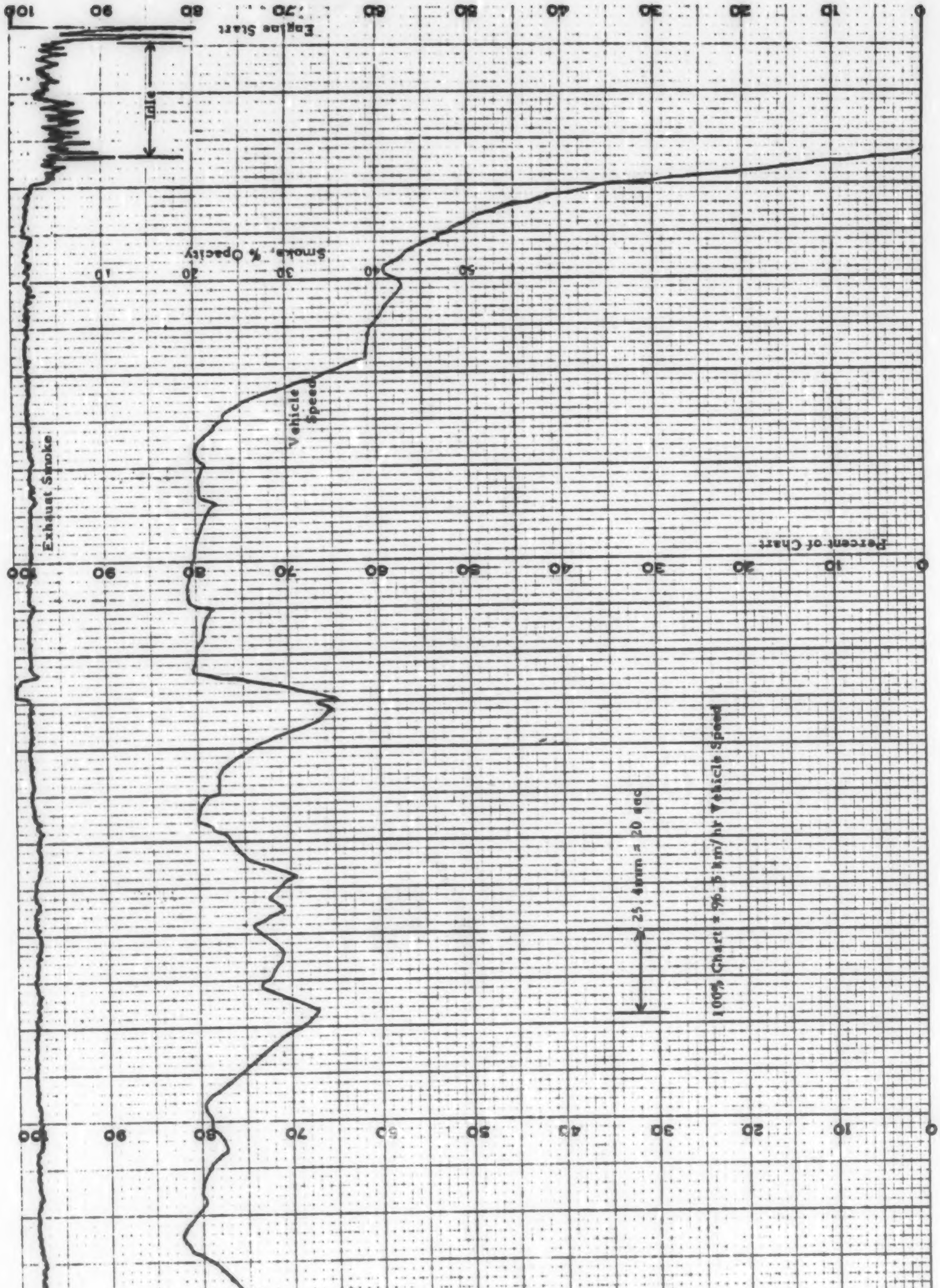

FIGURE 19. TYPICAL MERCEDES 300D FET SMOKE TRACE, FACTORY MUFFLER SYSTEM

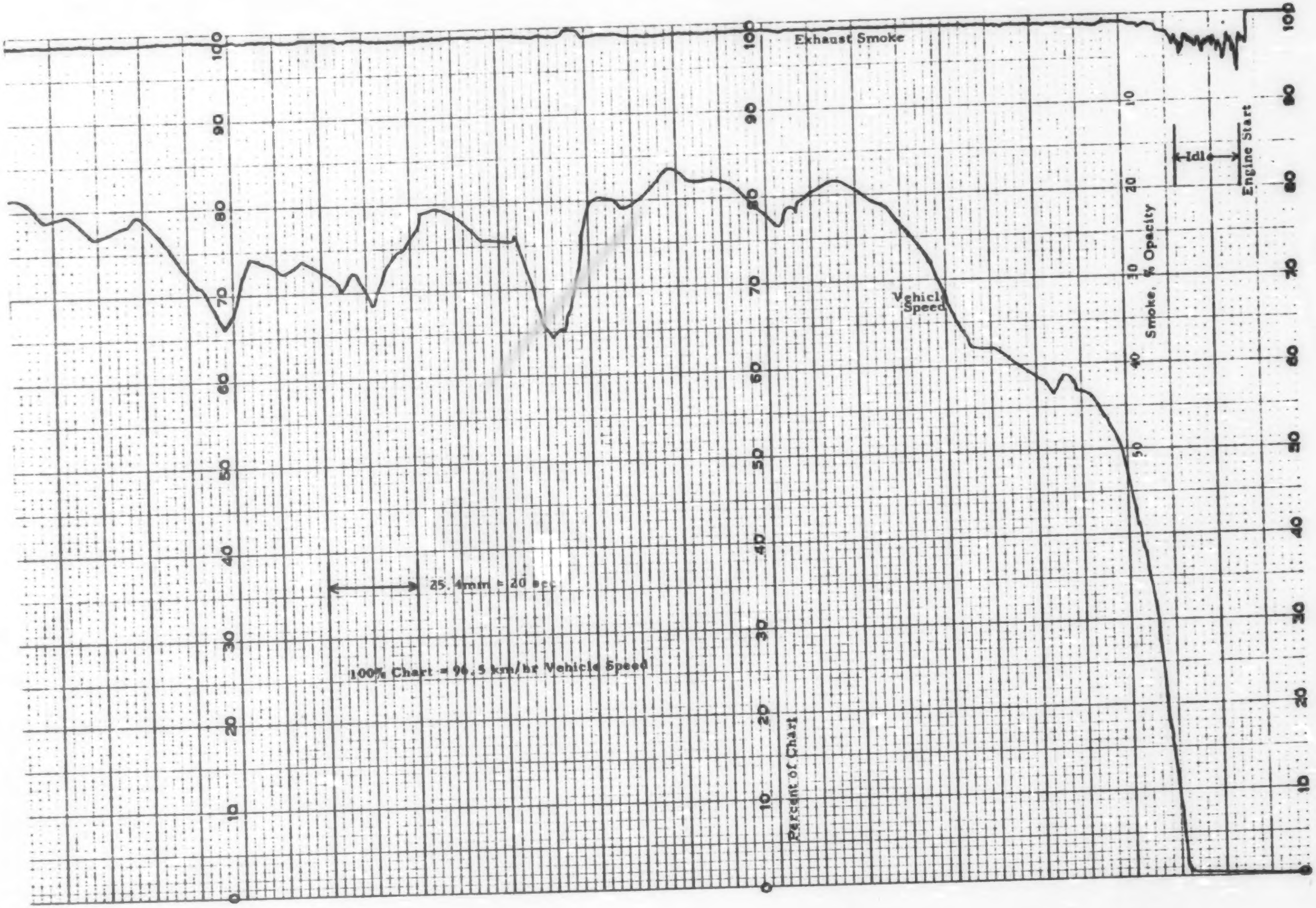

FIGURE 20. TYPICAL MERCEDES 300D FET SMOKE TRACE
A-IF, A-IR, TAV$_S$ TRAP SYSTEM

TABLE 11. TRANSIENT CYCLE EXHAUST EMISSIONS AND FUEL CONSUMPTION FACTORY AND TRAP SYSTEMS-MERCEDES 300D

Cycle	Configuration	Run	HC g/km	CO g/km	NO$_x$ g/km	Fuel Cons 1/100 km	Fuel Economy mpg
1975 FTP	Factory Exhaust	Part VII(1)	0.10	0.53	1.07	9.90	23.80
		1(2)	0.22	0.53	0.95	9.85	23.89
		2(2)	0.16	0.55	1.01	10.15	23.18
		Average	0.19	0.54	0.98	10.00	23.53
			(0.31)	(0.87)	(1.58)		
	A-IF, A-IR, TAV$_s$	1	0.06	0.47	0.86	8.88	26.50
		2	0.06	0.51	1.01	9.60	24.51
		3	0.05	0.47	0.91	9.33	25.22
		Average	0.06	0.48	0.93	9.27	25.41
			(0.10)	(0.77)	(1.49)		
FTP$_c$	Factory Exhaust	Part VII	0.10	0.55	1.10	10.53	22.36
		1	0.25	0.56	0.98	10.45	22.50
		2	0.17	0.55	1.01	10.15	23.16
		Average	0.21	0.55	0.99	10.30	22.83
			(0.34)	(0.88)	(1.59)		
	A-IF, A-IR, TAV$_s$	1	0.05	0.51	0.89	9.44	24.93
		2	0.07	0.54	1.02	10.01	23.51
		3	0.05	0.50	0.96	10.13	23.23
		Average	0.06	0.52	0.96	9.86	23.89
			(0.09)	(0.84)	(1.54)		
FTP$_h$	Factory Exhaust	Part VII	0.09	0.46	0.95	8.54	27.54
		1	0.14	0.50	0.98	9.16	25.66
		2	0.14	0.55	1.00	9.82	23.94
		Average	0.14	0.53	0.99	9.49	24.80
			(0.22)	(0.85)	(1.59)		
	A-IF, A-IR, TAV$_s$	1	0.06	0.42	0.84	8.15	28.87
		2	0.04	0.49	1.00	9.26	25.41
		3	0.06	0.44	0.86	8.49	27.71
		Average	0.05	0.45	0.90	8.63	27.33
			(0.08)	(0.72)	(1.45)		
SET	Factory Exhaust	Part VII	0.08	0.39	0.98	8.05	29.27
		1	0.10	0.38	0.86	8.05	29.26
		2	0.06	0.40	0.85	7.94	29.63
		Average	0.08	0.39	0.85	8.00	29.44
			(0.13)	(0.63)	(1.37)		
	A-IF, A-IR, TAV$_s$	1	0.05	0.35	0.82	7.48	31.45
		2	0.03	0.36	1.01	8.79	26.76
		3	0.04	0.34	0.80	7.89	29.81
		Average	0.04	0.35	0.88	8.05	29.34
			(0.06)	(0.56)	(1.42)		
FET	Factory Exhaust	Part VII	0.06	0.36	0.99	7.84	30.03
		1	0.06	0.34	0.86	7.81	30.12
		2	0.08	0.35	0.89	7.64	30.79
		Average	0.07	0.34	0.88	7.72	30.46
			(0.11)	(0.55)	(1.42)		
	A-IF, A-IR, TAV$_s$	1	0.04	0.31	0.79	6.98	33.70
		2	0.02	0.32	0.97	8.68	27.10
		3	0.04	0.31	0.88	7.75	30.35
		Average	0.03	0.31	0.88	7.80	30.38
			(0.05)	(0.50)	(1.42)		

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(1) From Part VII Final Report, runs made in November 1975.(28)

(2) Backpressure adjusted to 128mm Hg at 80.1 km/hr (50 mph)

(3) Average expressed in grams/mile

on the order of one-third to one-half that with the factory system. This is an interesting finding in that it indicates the particulate trap system is removing some of the unburned hydrocarbons, fuel, and/or partially burned oil from the exhaust and not just sulfuric acid mist. The reductions in HC from the trap point to other possibilities, such as reduced oxygenates or aldehydes, polynuclear aromatic compounds, odorants, etc.

Fuel consumption was slightly, on the order of 0.3 to 0.7 ℓ/100 km out of 8 to 10 ℓ/100 km, lower during the FTP with the trap system. This was reflected in a 1 to 1.5 mpg increase out of 25 to 28 mpg, a negligible and uncertain effect. During the SET, the fuel consumption was unchanged; while on the FET, the fuel consumption was slightly higher. The overall fuel consumption result is no change based on operating both exhaust systems at the same nomimal backpressure.

The data summarized on Table 11 is from the computer print-out sheets included as Appendix E. The run-to-run repeatability was quite satisfactory as evident from Table 11. For more details, please refer to Appendix E.

4. Odor Ratings

Table 12 is a summary of the odor panel ratings for the Mercedes 300D with and without the particulate trap installed. The three days of panel observations with the trap system are shown as an average in the first column. The factory system odor tests included both normal and increased backpressure experiments on August 9 and 11, 1976. For comparison, the two day average results obtained earlier and reported in Part VII final report(28) are listed. This summary is based on a substantial set of back-to-back measurements contained in Appendix F. The specific operating test conditions were defined in Table 14 in terms of engine speed, fuel rate, vehicle rear wheel power output and speed.

The last two columns of data on Table 12 are the net odor difference, in most cases a reduction, found when using the particulate trap system. Note the consistent and substantial changes in odor intensity and quality levels by comparing the trap to the factory exhaust system. This difference was lessened by comparing the trap to the factory exhaust set to the same backpressure as the trap system. Could it be that the increased exhaust backpressure had an influence on perceived exhaust odor? No research has been reported on such an effect since such an experiment has, to the author's knowledge, not been performed. The consistency of the results and the care in performing the experiment reinforce the validity of the data.

The really significant changes were noted at cold start and deceleration. Except for the acceleration condition, where the trap had no effect and backpressure also had no effect, the trap did result, for one reason or another, in lower perceived odor.

In one instance, during the highest speed, highest load run, an increase in odor was noted from the trap equipped car. Possibly this was due to some sort of purge of the trap, making the values higher by virtue of

TABLE 12. LISTING OF AVERAGE ODOR PANEL RATINGS-MERCEDES300D
(100:1 Dilution)

		Trap System	Factory System Installed			Odor Change	Odor Change
Vehicle Condition	Odor Kit	Installed (3 day avg)	Normal Backpressure (2 day avg)*	8/9/76	Increased BP 8/11/76	Factory (8/9/76) Minus Trap System	Factory (8/11/76) Minus Trap System
Steady State Results							
Intermediate Speed, No Load	D	1.4	2.3	2.3	1.7	0.9	0.3
	B	0.9	1.0	1.0	1.0	0.1	0.1
	O	0.4	0.9	0.9	0.5	0.5	0.1
	A	0.2	0.6	0.4	0.5	0.2	0.3
	P	0.2	0.5	0.3	0.4	0.1	0.2
Intermediate Speed, Mid Load	D	1.0	2.2	2.0	1.4	1.0	0.4
	B	0.8	1.0	1.0	0.9	0.2	0.1
	O	0.2	0.9	0.9	0.5	0.7	0.3
	A	0.1	0.5	0.3	0.4	0.2	0.3
	P	0.1	0.3	0.2	0.1	0.1	0
Intermediate Speed, High Load	D	1.0	2.0	2.0	1.1	1.0	0.1
	B	0.7	1.0	1.0	0.9	0.3	0.2
	O	0.2	0.9	1.0	0.3	0.8	0.1
	A	0.1	0.4	0.3	0.1	0.2	0
	P	0.1	0.3	0.2	0.2	0.1	0.1
High Speed, No Load	D	1.3	2.5	2.3	1.7	1.0	0.4
	B	0.9	1.0	1.0	0.9	0.1	0
	O	0.4	0.9	1.0	0.4	0.6	0
	A	0.2	0.7	0.3	0.4	0.1	0.2
	P	0.1	0.6	0.4	0.3	0.3	0.2
High Speed, Mid Load	D	1.8	3.0	2.9	2.2	1.1	0.4
	B	1.0	1.0	1.0	1.0	0	0
	O	0.6	1.0	1.0	0.7	0.4	0.1
	A	0.2	0.8	0.5	0.5	0.3	0.3
	P	0.3	0.6	0.6	0.4	0.3	0.1
High Speed, High Load	D	2.5	2.8	3.1	2.1	0.6	+0.4
	B	0.9	1.0	1.1	1.0	0.2	0.1
	O	0.8	1.0	1.0	0.7	0.2	+0.1
	A	0.4	0.7	0.4	0.4	0	0
	P	0.6	0.5	0.7	0.2	0.1	+0.4
Idle	D	1.5	2.9	2.2	1.7	0.7	0.2
	B	0.9	1.0	1.0	1.0	0.1	0.1
	O	0.4	1.0	0.8	0.4	0.4	0
	A	0.3	0.7	0.4	0.5	0.1	0.2
	P	0.2	0.6	0.3	0.2	0.1	0
Transient Results							
Idle-Accel	D	1.6	2.8	2.5	1.9	0.9	0.3
	B	0.9	1.0	1.0	1.0	0.1	0.1
	O	0.4	1.0	1.0	0.6	0.6	0.2
	A	0.5	0.7	0.4	0.4	+0.1	+0.1
	P	0.3	0.5	0.4	0.4	0.1	0.1
Acceleration	D	2.2	2.6	2.2	2.3	0	0.1
	B	1.0	1.0	1.0	1.0	0	0
	O	0.6	0.9	1.0	0.8	0.4	0.2
	A	0.4	0.7	0.3	0.5	+0.1	0.1
	P	0.6	0.4	0.3	0.5	+0.3	+0.1
Deceleration	D	1.2	2.5	2.7	2.2	1.5	1.0
	B	0.8	1.0	1.0	1.0	0.2	0.2
	O	0.3	1.0	1.0	0.8	0.7	0.5
	A	0.3	0.8	0.4	0.3	0.1	0
	P	0.1	0.4	0.7	0.4	0.6	0.3
Cold Start	D	0.8	3.4	3.4	2.9	2.6	2.1
	B	0.6	1.0	1.0	1.0	0.4	0.4
	O	0.1	1.0	1.0	1.0	0.9	0.9
	A	0.1	1.0	0.7	0.4	0.6	0.3
	P	0	0.7	0.9	0.8	0.9	0.8

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*Original tests of Mercedes 300D made on 4/14 and 4/16/76 at 8,106 kilometres.

the trapped odorants being driven off. Another theory is that some trapped unburned hydrocarbons, fuel or fuel-like substances, were partially oxidized during the highest temperature engine condition.

There are many ways to evaluate the odor data and Figure 21 is one way to show an odor "map", as well as compare test configurations. The top graphs show the "D" odor intensities to slightly increase or decrease with power. Notable is the slight decrease in odor with power, at 1740 rpm, while the opposite was true with 2900 rpm engine speed. These trends are fairly evident and occurred regardless of the exhaust configuration. The "D" intensities were lower with the trap system under nearly all speeds and loads, including idle.

The bar graphs at the bottom of Figure 21 depict the relative odor level for each configuration and all 11 conditions. Each condition is illustrated by a group of three bars. The first bar is a measure of the "D" + "B" + "O" + "A" + "P" average ratings for three replicate days of testing with the particulate trap. This representation gives about equal weight to the "D" intensity and the sum of the four quality ratings. The middle bar is for the factory exhaust system run at normal backpressure, while the third bar is for this same system at increased backpressure to simulate that imposed by the particulate trap system.

The center bar for the factory system was always the highest except for the accel during which no major differences were shown. The left bar, for the particulate trap, was always the lowest except during the high power at 2900 rpm. The extremely low value under the cold start condition was a surprise. An even greater surprise was the apparent effect of exhaust system backpressure on the odor with the factory system. The third bar was consistently lower than the factory system with normal backpressure, although not as low as the particulate trap.

To summarize the extensive odor measurements, the six steady states, idle cold start and three transients as well as all eleven conditions are averaged on Table 13. The "D" odor levels were lower overall with the traps and, according to the percent reductions, substantially so during the cold start. A 21 percent overall reduction in "D" odor intensity was found for the traps relative to the factory system with increased backpressure. An even greater reduction, on the order of 40 percent overall, was noted relative to the factory system at normal backpressure.

This improvement in observed odor was somewhat a surprise and the reason for it is not fully understood. The ability of the trap system to remove certain aerosols such as, for example, unburned fuel and oil mist expressed in terms of HC on Tables 11 and 14 and sulfate makes the apparent reduction in odor somewhat understandable.

5. Chemical Analyses During Odor Tests

Table 14 is a summary of the gaseous emissions measured in the raw exhaust at the same time odor measurements were taken. The values on Table 14 include the results of the tests made about four months earlier and reported in Part VII. HC were definitely higher during the previous

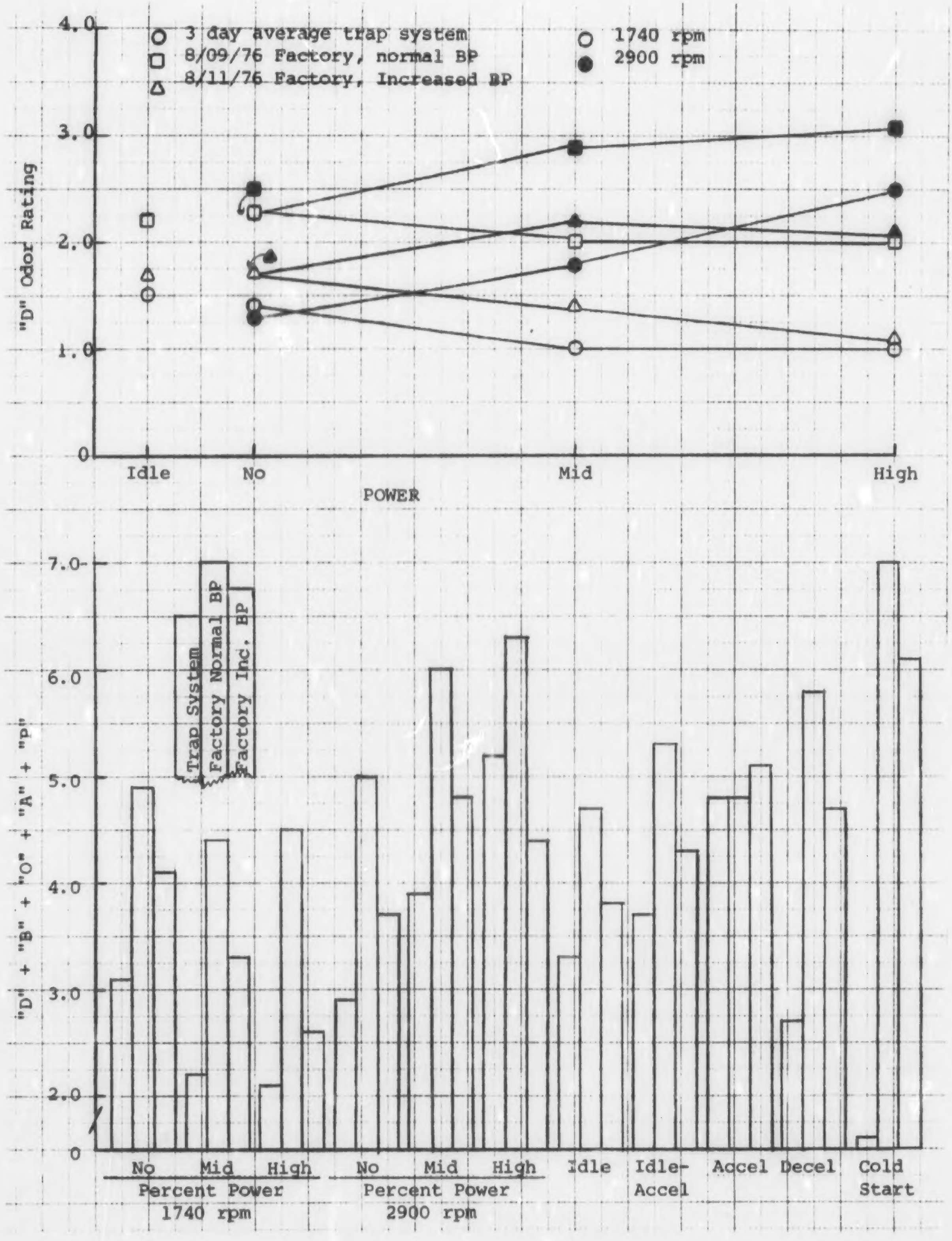

FIGURE 21. COMPARISON OF ODOR RATINGS FROM TRAP AND STANDARD EXHAUST EQUIPPED MERCEDES 300D

TABLE 13. ROUGH COMPARISON OF "D" ODOR RATINGS
MERCEDES 300D WITH/WITHOUT PARTICULATE TRAP SYSTEM

	Six Steady States	Idle	Cold Start	Three Trans.	All Eleven Conditions
Factory 4/1976(1)	2.5	2.9	3.4	2.6	2.6
Factory Normal BP	2.4	2.2	3.4	2.5	2.5
Factory Inc BP	1.7	1.7	2.9	2.1	1.9
Avg Traps	1.5	1.5	0.8	1.7	1.5
Percent Reduction(2)	37.5	31.8	76.5	32.0	40.0
Percent Reduction(3)	11.8	11.8	72.4	19.0	21.1

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(1) From Part VII Final Report runs made 4/1976.(28)

(2) $\frac{\text{Factory Normal Backpressure-Trap}}{\text{Factory Normal Backpressure}} \times 100\%$

(3) $\frac{\text{Factory Increased Backpressure-Trap}}{\text{Factory Increased Backpressure}} \times 100\%$

TABLE 14. EXHAUST ANALYSES TAKEN SIMULTANEOUSLY WITH ODOR RATINGS DURING STEADY STATE CONDITIONS-MERCEDES 300D

Vehicle Condition	Exhaust Emission	Factory System Installed			Trap System Installed (3 day avg.)	Change Factory (8/9/76) minus Trap System	Change Factory (8/11/76) minus Trap System
		Normal Backpressure (2 day avg)*	8/9/76	Increased BP 8/11/76			
Intermediate Speed, No Load	HC, ppmC	79	35	39	26	9	13
	CO, ppm	187	207	202	235	-28	-33
	NO-NDIR, ppm	71	86	77	104	-18	-27
	NO-CL, ppm	64	65	68	91	-26	-23
	NO_x-CL, ppm	73	80	83	94	-14	-11
	CO_2, %	2.6	2.4	2.9	2.6	- 0.2	0.3
	TIA	1.6	1.5	1.4	1.1	0.4	0.3
	LCO, µg/l	4.4	3.2	2.8	1.4	1.8	1.4
	LCA, µg/l	7.5	3.7	3.8	0.6	3.1	3.2
Intermediate Speed, Mid Load	HC, ppmC	68	36	33	24	12	9
	CO, ppm	146	183	169	201	-18	-32
	NO-NDIR, ppm	189	227	217	251	-24	-34
	NO-CL, ppm	167	172	167	206	-34	-39
	NO_x-CL, ppm	177	184	178	209	-25	-31
	CO_2, %	4.4	3.6	4.5	4.6	- 1.0	- 0.1
	TIA	1.7	1.5	1.4	1.2	0.3	0.2
	LCO, µg/l	5.1	3.1	2.4	1.7	1.4	0.7
	LCA, µg/l	9.8	4.0	3.8	0.8	3.2	3.0
Intermediate Speed, High Load	HC, ppmC	60	22	21	22	0	- 1
	CO, ppm	132	155	193	175	-20	18
	NO-NDIR, ppm	276	329	332	343	-14	-11
	NO-CL, ppm	243	247	253	285	-38	-32
	NO_x-CL, ppm	252	258	265	289	-31	-24
	CO_2, %	5.6	5.7	5.9	5.8	- 0.1	0.1
	TIA	1.7	1.5	1.3	1.2	0.3	0.1
	LCO, µg/l	4.7	3.4	2.1	1.6	1.8	0.5
	LCA, µg/l	8.0	4.4	2.8	0.8	3.6	2.0
High Speed, No Load	HC, ppmC	61	39	34	26	13	8
	CO, ppm	235	316	282	292	24	-10
	NO-NDIR, ppm	104	120	155	139	-19	16
	NO-CL, ppm	88	90	105	120	-30	-15
	NO_x-CL, ppm	98	101	118	124	-23	- 6
	CO_2, %	3.1	3.0	3.5	3.4	- 0.4	0.1
	TIA	1.7	1.5	1.4	1.3	0.2	0.1
	LCO, µg/l	4.2	3.2	2.3	2.2	1.0	0.1
	LCA, µg/l	8.0	5.3	3.7	1.1	4.2	2.6
High Speed, Mid Load	HC, ppmC	43	11	9	24	-13	-15
	CO, ppm	159	183	178	205	-22	-27
	NO-NDIR, ppm	341	393	409	435	-42	-26
	NO-CL, ppm	312	323	333	364	-41	-31
	NO_x-CL, ppm	320	327	337	369	-42	-32
	CO_2, %	6.4	6.3	7.1	7.3	- 0.1	- 0.2
	TIA	1.7	1.6	1.3	1.5	0.1	- 0.2
	LCO, µg/l	5.2	4.0	2.2	2.8	1.2	- 0.6
	LCA, µg/l	8.8	4.5	2.6	3.4	1.1	- 0.8
High Speed, High Load	HC, ppmC	46	13	16	47	-34	-31
	CO, ppm	148	169	160	262	-93	-102
	NO-NDIR, ppm	490	547	565	531	16	34
	NO-CL, ppm	456	450	444	449	1	- 5
	NO_x-CL, ppm	464	452	450	453	- 1	- 3
	CO_2, %	9.4	9.2	10.4	10.5	- 1.3	- 0.1
	TIA	1.8	1.6	1.4	1.6	0	- 0.2
	LCO, µg/l	5.5	4.2	3.0	3.6	0.6	- 0.6
	LCA, µg/l	8.1	5.0	4.3	5.8	- 0.8	- 1.5
Idle	HC, ppmC	119	71	50	43	28	7
	CO, ppm	172	188	197	256	-68	-59
	NO-NDIR, ppm	104	112	158	134	-22	24
	NO-CL, ppm	85	90	117	112	-22	5
	NO_x-CL, ppm	95	105	130	120	-15	10
	CO_2, %	2.5	2.5	2.7	2.7	- 0.2	0
	TIA	1.7	1.5	1.2	1.3	0.2	- 0.1
	LCO, µg/l	4.6	3.3	1.6	1.8	1.5	- 0.2
	LCA, µg/l	10.6	4.5	2.8	1.3	3.2	1.5

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* Original tests of Mercedes 300D made on 4/14 and 4/16/76 at 8106 km

evaluation than with the factory system at either normal backpressure on 8/9/76 or at increased backpressure on 8/11/76. The effect of backpressure on the gaseous emissions was to produce some higher, some lower and some unchanged with no real trend necessarily evident.

The last two columns of Table 14 show the difference between the normal backpressure and the trap system and between the increased backpressure and the trap system. Most of the net differences are negative (-) meaning the emissions increased with the trap. HC reacted both ways, decreasing during the 1740 rpm, no and mid power modes, 2900 rpm, no load mode and the idle. The opposite was true during two modes at 2900 rpm, mid and high load. Only occasionally were the differences considered of major importance and the lack of consistency makes the effect of the trap on gaseous emissions of little apparent significance. For more, detailed, data for each run in each configuration, refer to Appendix F.

6. Odor by DOAS

An indication of exhaust odor was evaluated by the DOAS during both steady-state and transient vehicle operation.

a. Steady State Results - Also listed on Table 14 are the average DOAS results summarized in Appendix F. These results, in terms of LCA, LCO and TIA,are best illustrated by plotting TIA versus "D" intensity by the odor panel. This is shown on Figure 22. The agreement between the odor intensity by the two, quite different methods, is somewhat encouraging in that if odor by the panel was lower or higher, then TIA was likewise lower or higher.

Note the solid, or full load, points cover a wide range of odor intensities from "D"-0.9 up to "D"-3.1. The net difference values on Table 14 consistently show reductions in LCO, LCA and TIA with the trap system. The greatest difference, and most consistent, was found when compared to the factory system at normal backpressure. The increased backpressure factory system resulted in lower TIA and therefore, when compared to this configuration, the trap had less relative effect. Thus, the TIA gives the same basic conclusion and tends to rank the configurations in the same order as the odor panel ratings.

b. Transient Results - Table 15 is a summary of the DOAS results of samples collected during various transient cycles. Listed first are the results reported in Part VII. The TIA values obtained on 7/19/76 are all higher than those initially obtained in November 1975. The TIA values are not greatly different even though the LCO and LCA values appear for the FET cycle quite different, higher than the FTP and SET cycles.

The important item from Table 15 is the fairly consistent run-to-run DOAS results with the particulate trap system. These results are very low, relative to either factory system. The net differences and percent reductions, shown on Table 15, indicate the effect of the trap system during cold start 1975 FTP, the SET and FET cycles. TIA reductions of about 46 to 72 percent are listed.

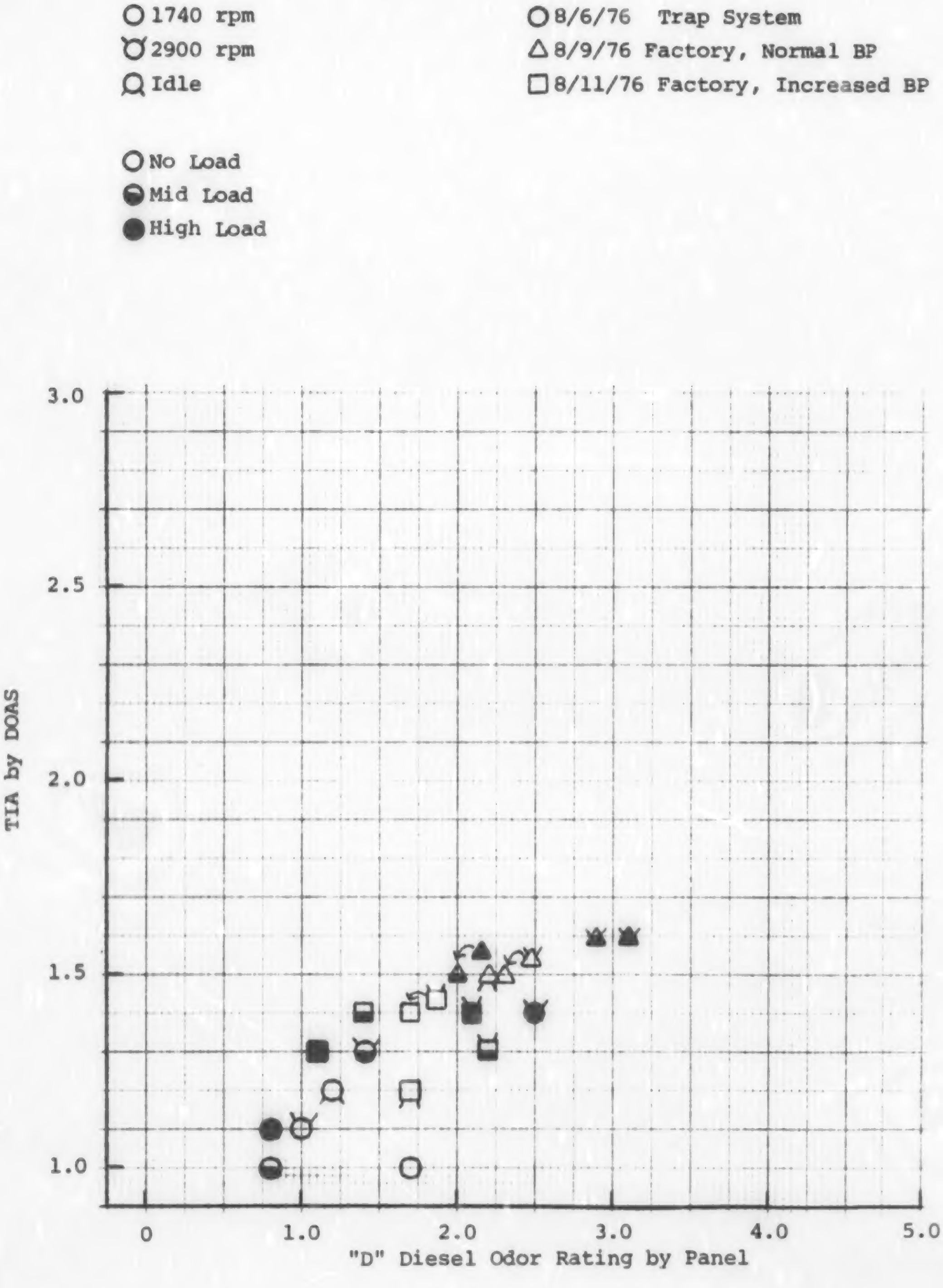

FIGURE 22. TIA BY DOAS VERSUS "D" ODOR RATING BY TRAINED PANEL FOR TRAP AND FACTORY EXHAUST CONFIGURATIONS-MERCEDES 300D

TABLE 15. DOAS RESULTS DURING VARIOUS TRANSIENT CYCLES MERCEDES 300D WITH/WITHOUT PARTICULATE TRAP SYSTEM

		DOAS RESULTS								
	Run	LCA, μg/ℓ			LCO, μg/ℓ			TIA		
	No.	FTP	FET	SET	FTP	FET	SET	FTP	FET	SET
Factory (11/1975)(1)	Avg	1.43	2.27	1.45	0.73	1.33	0.92	0.86	1.12	0.89
Factory Normal BP (7/1976)		3.40	2.03	2.75	1.39	1.57	1.40	1.14	1.20	1.15
Particulate Traps	1	0.84	0.43	0.53	0.38	0.51	0.38	0.58	0.71	0.58
	2	0.33	0.76	0.41	0.19	9.59	0.23	0.27	0.77	0.37
	3	0.24	0.40	0.24	0.13	0.30	0.15	0.11	0.48	0.17
	Avg	0.47	0.53	0.39	0.23	0.47	0.25	0.32	0.65	0.37
Net Difference Factory (7/1976)-Traps		2.93	1.50	2.36	1.16	1.10	1.15	0.82	0.55	0.78
% Reduction		86.2	73.9	85.8	83.5	70.1	82.1	71.9	45.8	67.8

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(1) From Part VII Final Report runs made November 1975.(28)

The bar graphs of Figure 23 illustrate the values listed on Table 15. It should be remembered that the samples are collected continuously throughout the driving cycle and are obtained to only give some relative indication of odor during transient operation. Of interest is the effect of cycle average speed and duty cycle on producing more LCO and, of course, TIA. The same stairstep appearance is evident for the particulate trap system LCA and TIA.

7. Aldehydes

Due to a series of instrument problems, no valid aldehyde data can be reported. It may be speculated, however, that the aldehydes were likely trapped, especially the higher molecular weight of the group, such as crotonal, hexanal, and benzaldehyde. This speculation is backed up by the other evidence of reduced odor, exhaust hydrocarbons, and BaP.

8. Detailed Hydrocarbon Measurements

Measurement of various HC's in the exhaust were obtained during both steady state, odor test conditions, as well as during the various transient cycles.

a. Steady State Results - Table 16 lists as-measured concentrations of the various HC emissions measured during the seven steady state odor test conditions. Listed first are the previously reported data for this car for comparison. The runs made on 8/9/76 were with normal backpressure. Generally, the standard system tested on 8/9/76 gave the same, or more often, lower concentrations than the original test series. In many cases, the two factory exhaust system tests gave results of good approximation to one another in light of the test procedure.

Just as the 8/9/76 results were generally lower than the original test, so were the results with the trap system generally, although not always, higher than the 8/9/76. Overall, it is hard to discern a consistent difference as indicated by the plus and minus "difference" values of Table 16.

b. Transient Cycle Results - Table 17 lists the nonreactive hydrocarbon values in mg/km by the various transient procedures. Listed in the first column are the results obtained about eight months earlier with the standard car from Part VII final report. For the most part, methane, ethylene, and acetylene values are comparable except for the FTP methane, which was higher. Of interest was the presence of ethane, propylene, benzene and toluene that was not reported detectable, or negligible, in the earlier tests.

The third column of Table 17 lists the HC results, with the trap system installed. The back-to-back tests reveal generally small differences, except for methane and ethylene. Why these hydrocarbons were lower, on the order of 20 percent, with the trap system is unknown.

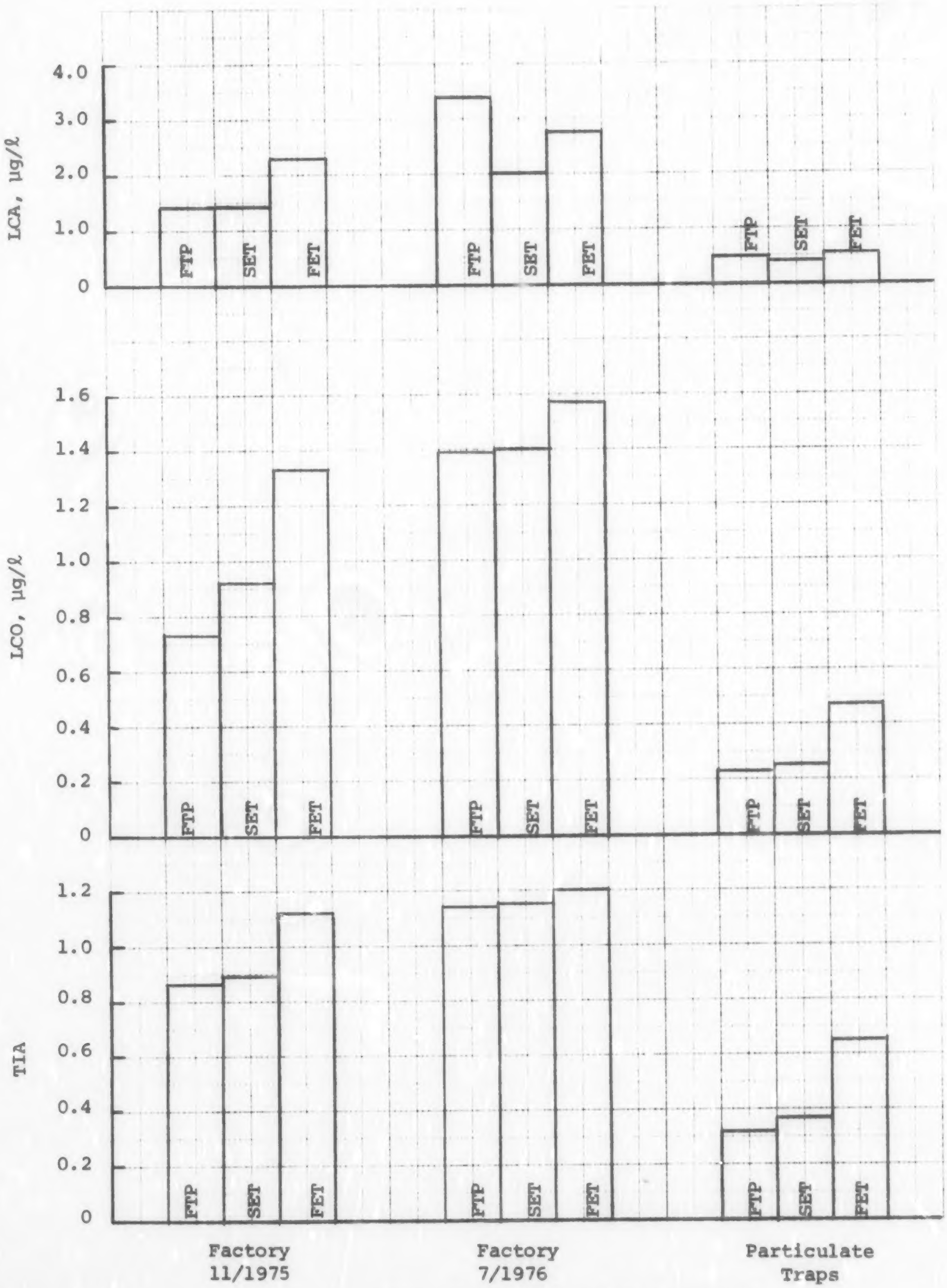

FIGURE 23. DOAS RESULTS FOR SAMPLES OBTAINED DURING VARIOUS TRANSIENT CYCLES

TABLE 16. DETAILED HYDROCARBON ANALYSIS OF SAMPLES TAKEN DURING STEADY STATE ODOR TESTS

		ppmC							
Vehicle Condition	Configuration	Methane CH_4	Ethylene C_2H_4	Ethane C_2H_6	Acetylene C_2H_2	Propane C_3H_8	Propylene C_3H_6	Benzene C_6H_6	Toluene C_7H_8
Intermediate Speed, No Load	Factory(1)	4.1	8.1	0.3	1.3	tr*	2.3	2.0	0.6
	Factory	3.0	7.3	0.2	1.5	0.0	2.1	1.5	0.2
	Trap System	4.2	8.4	0.4	1.6	tr	2.6	1.0	0.9
	Difference	-1.2	-1.1	-0.2	-0.1	---	-0.5	0.5	-0.7
Intermediate Speed, Mid Load	Factory(1)	3.9	8.7	0.4	1.2	tr	2.5	2.0	0.4
	Factory	2.5	8.4	0.3	1.9	tr	2.5	1.3	0
	Trap System	3.0	7.6	0.3	1.5	tr	2.2	1.5	0.6
	Difference	-0.5	0.8	0	0.5	---	0.3	-0.2	-0.6
Intermediate Speed, High Load	Factory(1)	3.2	6.5	0.3	0.9	tr	1.7	1.3	0.2
	Factory	1.7	5.9	0.2	1.3	0.1	1.6	0.6	0
	Trap System	2.1	5.2	0.2	1.2	tr	1.4	1.3	0.6
	Difference	-0.4	0.7	0	0.1	0.1	0.2	-0.7	-0.6
High Speed, No Load	Factory(1)	5.8	9.3	0.5	1.7	tr	2.2	2.8	0.7
	Factory	5.7	10.1	0.6	2.8	tr	2.2	2.7	0.4
	Trap System	5.8	11.7	0.7	2.4	0.2	3.9	1.4	0.5
	Difference	-0.1	-1.6	-0.1	0.4	-0.2	-1.7	1.3	-0.1
High Speed, Mid Load	Factory(1)	3.5	5.4	0.3	1.1	tr	1.1	0.9	0.3
	Factory	1.3	3.8	0.1	1.0	0.0	0.8	1.1	0
	Trap System	0.6	3.7	0.1	1.1	tr	1.5	4.2	0.4
	Difference	0.7	0.1	0	-0.1	---	-0.7	-3.1	-0.4
High Speed, High Load	Factory(1)	3.2	4.5	0.2	1.1	0	1.0	1.2	0.2
	Factory	1.1	3.6	0.1	1.1	0.0	0.9	1.0	0
	Trap System	1.4	3.8	0.1	1.2	tr	0.9	1.8	1.0
	Difference	-0.3	-0.2	0	-0.1	0	0	-0.8	-1.0
Idle	Factory(1)	4.8	10.1	0.6	1.6	0.1	3.2	2.9	0.8
	Factory	3.5	7.7	0.4	1.6	tr	2.5	1.8	0.3
	Trap System	4.6	9.2	0.3	2.0	tr	2.4	1.9	0.8
	Difference	-1.1	-1.5	0.1	-0.4	---	0.1	-0.1	-0.5

(1) From Part VII Final Report runs made November 1976.(28)

* tr - trace

Factory 8/9/76, normal backpressure

Trap System 9/4/76

TABLE 17. DETAILED HYDROCARBON ANALYSIS OF SAMPLES TAKEN DURING VARIOUS TRANSIENT CYCLES

		Emission Rate, mg/km			
Emission	Cycle	Factory 11/75[1]	Factory 7/2/76[2]	Trap System	Difference 7/2/76-Trap System
Methane	FTP	3.94	7.63	6.00	1.63
	SET	3.34	3.45	2.36	1.09
	FET	4.25	2.86	1.76	1.10
Ethylene	FTP	14.49	15.34	12.82	2.52
	SET	9.39	9.93	6.92	3.01
	FET	8.49	8.38	5.04	3.34
Ethane	FTP	0.0	0.78	0.78	0
	SET	0.0	0.44	0.44	0
	FET	0.0	0.32	0.32	0
Acetylene	FTP	2.81	2.47	1.60	0.87
	SET	trace	1.92	1.13	0.79
	FET	3.50	1.67	0.82	0.85
Propane	FTP	0.0	0.0	0.0	0
	SET	0.0	0.0	0.0	0
	FET	0.0	0.0	0.62	-0.62
Propylene	FTP	0.0	4.11	3.71	0.40
	SET	0.0	2.48	1.63	0.85
	FET	0.0	2.09	1.18	0.91
Benzene	FTP	0.0	5.22	4.58	0.64
	SET	0.0	2.86	2.41	0.45
	FET	0.0	2.36	2.63	-0.27
Toluene	FTP	0.0	3.71	2.11	1.60
	SET	0.0	0.0	0.0	0
	FET	0.0	0.0	0.58	-0.58

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(1) From Part VII Final Report, runs made in November 1975.(28)

(2) Backpressure adjusted to 128 mm Hg at 80.1 km/hr (50 mph).

9. BaP Results

The 8 x 10 size filters, described earlier, were used to obtain the particulate samples for BaP analysis. These filters were obtained during the three transient test cycles. The reductions in BaP, shown on Table 18, were quite substantial, ranging from 25 percent during the FTP hot 23 minute run, to 79 percent during the SET. The reduction during the 23 minute cold FTP was 51 percent to give a combined 1975 FTP result of 33 percent. A 58 percent reduction during the FET was found. Overall, a reduction in BaP, regardless of method of expression, of about 50 percent, was found when the particulate trap system was used.

These are substantial reductions which are consistent with the overall reduction of hydrocarbons and sulfuric mist. Exactly why the trap system appears to be more effective during the SET and least effective during the 23 min FTP from hot start is unknown. The reductions are significant and represent important documented evidence of the trapping and removal of BaP from diesel exhaust.

10. Carbon, Hydrogen and Nitrogen Measurements

Table 19 lists the percent carbon, hydrogen and nitrogen found in the particulate collected by the 47mm fiberglass filter discs. The two runs listed represent two different days of operation for each exhaust configuration. In most cases, the run to run repeatability was quite good.

To attempt placing the carbon and hydrogen analyses into some perspective, a hydrocarbon to carbon (H/C) ratio was calculated in which the two percentages found are assumed to represent 100 percent of the filter weight. This calculation is shown on Table 19 and reveals that during both cold and hot FTP operation, the ratio of hydrogen to carbon on the filter increased meaning that much more carbon was removed by the trap than hydrogen containing particulate such as unburned fuel or oil mist. This is not to say that the trap was not removing both carbon and hydrogen containing materials, but that it was apparently removing more carbon particulate.

During the SET and FET, the H/C ratio did not follow the same trend as during the FTP meaning that the trap system was not as preferential to the predominately carbon particles as in the lower temperature lower duty cycle tests. The SET and FET usually produce lower overall unburned hydrocarbons and this may be a reason.

The nitrogen values on Table 19 indicate the trap releases nitrogen, or a compound that analyzes as nitrogen. There is no obvious explanation for this behavior and it is recommended that these values be used with caution. It could be that the increased percent nitrogen on the filter was influenced by a gross reduction of other contaminants and is, in reality, no change.

11. Noise Measurements

Table 20 is a summary of the noise measurements made with the particulate trap equipped Mercedes 300D. Also listed are the results of the

TABLE 18. BaP EMISSION RATES WITH AND WITHOUT PARTICULATE TRAPS-MERCEDES 300D

Test	Rate	Factory Normal BP	Trap System	Difference (Fact-Trap)	% Reduct.
1975 FTP	mg/hr	0.226	0.151	0.075	33.2
	mg/kg fuel	0.062	0.042	0.020	33.3
	μg/km	7.207	4.810	2.397	33.3
FTP_{cold}	mg/hr	0.160	0.078	0.082	51.3
	mg/kg fuel	0.041	0.020	0.021	51.2
	μg/km	5.088	2.490	2.598	51.1
FTP_{Hot}	mg/hr	0.276	0.207	0.069	25.0
	mg/kg fuel	0.078	0.058	0.020	25.6
	μg/km	8.806	6.560	2.246	25.5
SET	mg/hr	0.261	0.055	0.206	78.9
	mg/kg fuel	0.058	0.012	0.046	79.3
	μg/km	4.664	0.984	3.680	78.9
FET	mg/hr	0.273	0.115	0.158	57.9
	mg/kg fuel	0.038	0.016	0.022	57.9
	μg/km	3.528	1.484	2.044	57.9

TABLE 19. CARBON, HYDROGEN AND NITROGEN ANALYSES OF PARTICULATE COLLECTED ON 47mm FIBERGLASS

Test	Exhaust	Carbon, %			Hydrogen, %			$\frac{H}{C}$	Nitrogen, %		
Type	Config.	Run 1	Run 2	Avg.	Run 1	Run 2	Avg.		Run 1	Run 2	Avg.
FTP_c	Factory	79.1	78.6	78.9	3.6	3.6	3.6	0.54	0.7	0.6	0.7
	Trap	78.0	70.6	74.3	4.7	4.2	4.4	0.71	1.5	---	1.5
FTP_h	Factory	70.5	79.9	75.2	4.0	3.9	4.0	0.63	0.6	0.5	0.6
	Trap	78.3	73.2	75.8	4.8	5.4	5.1	0.81	1.5	---	1.5
SET	Factory	68.7	63.3	66.0	3.5	3.6	3.5	0.64	0.5	0.4	0.5
	Trap	80.3	80.3	80.3	3.7	3.7	3.7	0.55	1.3	---	1.3
FET	Factory	67.8	53.6	60.7	4.4	4.0	4.2	0.83	0.7	0.7	0.7
	Trap	71.4	70.6	71.0	5.4	4.8	5.1	0.86	1.6	---	1.6

TABLE 20. SUMMARY OF SOUND LEVEL MEASUREMENTS - dBA SCALE MERCEDES 300D

	Factory System from Part VII	Trap System Installed	Difference Trap-Fact.	Percent Increase
SAE J986a				
Accel Driveby				
Exterior Right to Left	71.5	84	12.5	14.9
Left to Right	71.8	78	6.2	7.9
Interior				
Blower On (a)	79	79	0.0	0.0
Off	76.5	77	0.5	0.6
48.3 km/hr Driveby				
Exterior Right to Left	59.5	60.8	1.3	2.1
Left to Right	58.8	60.5	1.7	2.8
Interior				
Blower On (a)	75.8	74	-1.8	-2.4
Off	63.8	69.5	5.7	8.2
Engine Idle				
Exterior (b)	67	74	7	9.5
Interior				
Blower On (a)	68.5	68.5	0	0
Off	54.5	58	3.5	6.0

(a) Windows up, fresh air blower on high

(b) At 3.05 m

test made with the factory exhaust system in July 28, 1975 and previously included in the Part VII final report.(28) The summary data are derived from the more detailed replicate runs listed in Appendix G.

The difference column in Table 20 shows that during the SAE drive-by exterior test that the trap-equipped car was noisier than the standard factory-equipped car. The right to left reading was 12.5 dBA higher than standard and to a large extent was due to the exhaust exit pointing directly toward the side of the road. The sound level meter registered the directional noise which apparently was generated by and emanated from the TAV_S exhaust exit. When the acceleration test was performed in the opposite direction (left to right) with the sound meter on the passenger (right) side of the car, the noise was about 6 dBA higher. The meter was apparently still sensitive to the increased exhaust noise as it passed through the trap system and the noises produced by the exhaust and exiting from the TAV_S separator.

The interior measurements, made with the fresh air blower off, were noticeably higher with the particulate system, on the order of 5.7 dBA during the 48.3 km/hr cruise and 3.5 dBA during the idle. When the blower was turned on, it masked the extra noise from the exhaust system. The particulate system equipped Mercedes was only slightly louder than the factory exhaust during the cruise at 48.3 km/hr. The increase amounted to 1.3 and 1.7 dBA and was due apparently to the change in exhaust direction, horizontally and transverse to the car direction instead of longitudinally with the car direction.

The increase in noise is of interest from a documentation standpoint but should not be considered indicative of what a well designed system might produce. The TAV_S was merely attached to the exit of the tailpipe at bumper level and the exhaust pointed from the TAV_S horizontal and transverse to the vehicle.

12. Performance

The backpressure imposed on the engine exhaust by the front A-IF, rear A-IR Texaco agglomerators and the Ethyl TAV_S separator was appreciable. In fact, the increase in backpressure due to the trap system was about 178 mm Hg at 80.5 km/hr (50 mph). This would be expected to impede performance under wide-open throttle (WOT) acceleration.

To investigate the extent to which acceleration was affected, a series of WOT's were made and are compared in Table 21 with the standard exhaust system and backpressure of the same vehicle tested during the original evaluation and reported in Part VII.(28) The increase in time for the 0-64.4 km/hr (0-40 mph) was 1.5 sec or a 13.9 percent. The increase in time for the 0-96.5 km/hr (0-60 mph) accel was 4.6 sec or 20.4 percent, while the 32.3-96.5 km/hr (20-60 mph) time was 4.1 sec or 21 percent.

These are significant increases in acceleration times and represent a noticeable reduction in vehicle performance during those driving situations involving maximum acceleration rate. It is uncertain how the trap system could be redesigned to reduce the substantial backpressure experienced and thereby regain the loss in WOT accel performance. Certainly,

TABLE 21. ACCELERATION TIMES FOR MERCEDES 300D WITH AND WITHOUT PARTICULATE TRAP SYSTEM
(Windows up, air conditioner off)

Exhaust Config.	Direction	0-64.4 km/hr[1] Time, Sec.	0-96.5 km/hr[2] Time, Sec.	32.2-96.5 km/hr[3] Time, Sec.
Factory	N	10.8	22.7	19.6
System	S	10.8	22.3	19.3
	Avg.	10.8	22.5	19.5
Trap	N	12.5	27.7	23.3
System	S	11.9	26.6	23.9
	Avg.	12.3	27.1	23.6
Net Increase in Time, Sec.		1.5	4.6	4.1
Percent Increase in Accel Time		13.9	20.4	21.0

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(1) 0-40 mph
(2) 0-60 mph
(3) 20-60 mph

some improvements can likely be made without loss in particulate removal efficiency. It is felt, however, that particulate agglomeration and separation will no doubt require some work to be done on the gas in terms of some pressure drop. If the gas is not accelerated and made to do certain things, the particulate will likely pass through the system and not be collected. There is, no doubt, a point of optimum removal for the backpressure imposed. Work needs to be done along these lines but was beyond the scope of this project. In the system's current configuration, it was considered satisfactory to demonstrate "proof of principle" but was not considered satisfactory otherwise.

D. Durability Evaluation

The third major segment of the work plan involved accumulating 16,090 km (10,000 mi) of operation over the modified MVMA driving cycle with the trap equipped Mercedes 300D. The two top photos of Figure 24 depict two views of the entire trap system including the interconnecting exhaust piping. Also shown in each of these views is the standard factory exhaust system for comparison. The two center views and lower left view illustrate the installation of the trap system. As shown, the A-IF and A-IR just barely fitted under the car as they were intentionally made as large as possible. The TAV_s was close-coupled to the A-IR outlet yet was located beyond the bumper and oriented so the exhaust exited horizontally and to the left or street side of the car. The lower right view is with the exit cone removed from the A-IR unit.

1. Effect of Trap System on Particulate Emissions

Insofar as the effectiveness of the particulate trap system is concerned, the durability testing is considered an extension of the already 2853 km (1767 mi) of operation on the A-IR and the 2041 km (1268 mi) on the A-IF agglomerators accumulated during the screening and evaluative testing. Figure 14, presented earlier, illustrated the baseline and various systems involving the Texaco packed agglomerators during screening. The efficiency decreased some during the 1161 km (1001 mi) on A-IR during the screening tests.

The efficiency of the trap system components versus amount of operation are summarized on Table 22. The first part of Table 22 is captioned "Screening" and is a restatement of results involving either the A-IR or A-IF either alone or in conjunction with the TAV_s. The distance operated is given and represents mainly that accumulated during the extensive chassis dynamometer testing. The most important column on Table 22 is the percent reduction. Note that on the order of 66 percent reduction in particulate was obtained when the A-IR was new. At the conclusion of the screening tests, the A-IR had accumulated 1611 km, A-IF 799 and the A-IF, A-IR, TAV_s combination was about 50 percent effective.

The next set of values on Table 22 are those obtained during the evaluation phase of the project. Note that efficiency at this point (1727 km) A-IF, 915 km A-IR was about 33 percent by the FTP_c or FTP_h. The 1975 FTP is a mathematical combination by the following:

$$1975\ FTP = 0.43\ FTP_c + 0.57\ FTP_h$$

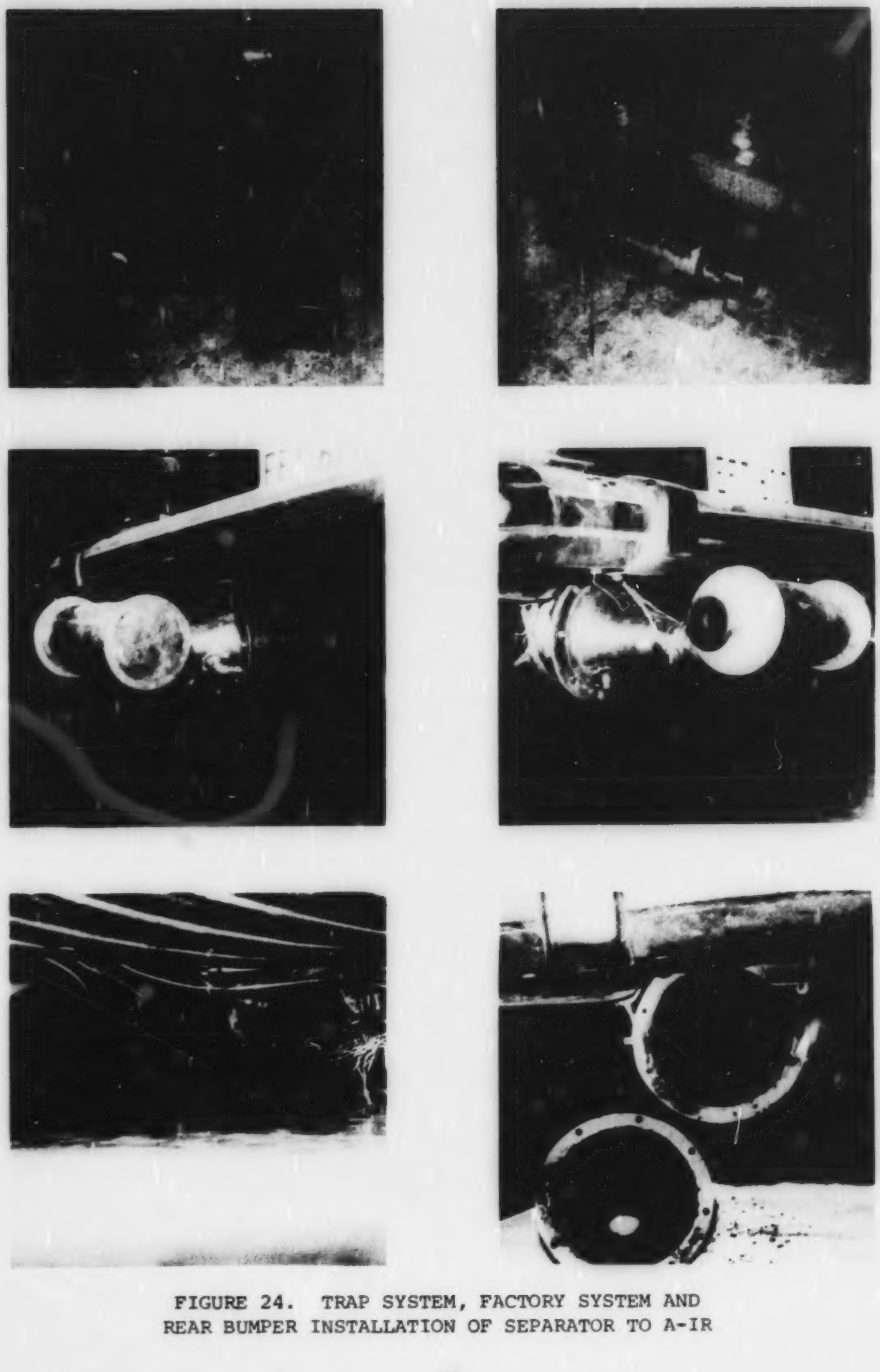

FIGURE 24. TRAP SYSTEM, FACTORY SYSTEM AND REAR BUMPER INSTALLATION OF SEPARATOR TO A-IR

TABLE 22. HISTORY OF TRAP SYSTEM AND SYSTEM COMPONENT PARTICULATE REMOVAL EFFICIENCIES FROM INITIAL SCREENING TO FINAL DURABILITY TEST

Test Point	Test Type	Distance, km A-IR	Distance, km A-IF	Factory BP(1)	Factory g/km	Trap System Description	Trap System g/km	Red. %
				Screening				
Initial	FTP_c	0	---	a	0.282	A-IR New	0.097	65.6
	FTP_h	0	---	a	0.267	A-IR New	0.090	66.3
	1975 FTP							66.0
Screen	FTP_c	268	---	a	0.282	A-IR + TAV_s	0.168	40.4
	FTP_h	268	---	a	0.267	A-IR + TAV_s	0.123	53.9
	1975 FTP							48.1
Initial	FTP_c	----	0	a	0.363	A-IF New	0.256	29.5
	FTP	----	0	a	0.278	A-IF New	0.209	24.8
	1975 FTP							26.8
Screen	FTP_c	709	141	a	0.363	A-IF + A-IR	0.176	51.5
	FTP_h	709	141	a	0.278	A-IF + A-IR	0.099	64.4
	1975 FTP							58.8
Screen	FTP_c	----	322	a	0.339	A-IF + TAV_s	0.258	23.9
	FTP_h	----	322	a	0.303	A-IF + TAV_s	0.179	40.9
	1975 FTP							33.3
Screen	FTP_c	890	426	a	0.339	A-IF, A-IR, TAV_s	0.113	66.7
	FTP_h	890	426	a	0.303	A-IF, A-IR, TAV_s	0.092	69.6
	1975 FTP							68.4
Screen	FTP_h	1611	799	a	0.326	A-IF, A-IR, TAV_s	0.165	49.4
				Evaluation				
Eval	FTP_c	1727	915	b	0.332	A-IF, A-IR, TAV_s	0.220	33.7
	FTP_h	1727	915	b	0.268	A-IF, A-IR, TAV_s	0.181	32.5
	1975 FTP							32.9
	SET	1727	915	b	0.204	A-IF, A-IR, TAV_s	0.137	32.8
	FET	1727	915	b	0.201	A-IF, A-IR, TAV_s	0.117	41.8

TABLE 22. (Contd) HISTORY OF TRAP SYSTEM AND SYSTEM COMPONENT PARTICULATE REMOVAL EFFICIENCIES FROM INITIAL SCREENING TO FINAL DURABILITY TEST

Test Point	Test Type	Distance, km A-IR	Distance, km A-IF	Factory BP(1)	Factory g/km	Trap System Description	Trap System g/km	Red. %
				Durability				
Start	FTP$_c$	2853	2041	b	0.332(3)	A-IF, A-IR, TAV$_s$	0.220	33.7
Durab.	FTP$_h$	2853	2041	b	0.268(3)	A-IF, A-IR, TAV$_s$	0.181	32.5
	1975 FTP							32.9
2500	FTP$_c$	6875	6063	b	0.332(4)	A-IF, A-IR, TAV$_s$	0.345	- 3.6
Durab.	FTP$_h$	6875	6063	b	0.268(4)	A-IF, A-IR, TAV$_s$	0.246	8.2
	1975 FTP							3.1
5000	FTP$_c$	10898	10086	b	0.289	A-IF, A-IR, TAV$_s$	0.281	3.1
Durab.	FTP$_h$	10898	10086	b	0.250	A-IF, A-IR, TAV$_s$	0.229	8.8
	1975 FTP							6.4
	SET	10898	10086	b	0.209	A-IF, A-IR, TAV$_s$	0.209	0
	FET	10898	10086	b	0.161	A-IF, A-IR, TAV$_s$	0.194	-21.3
7500 Durab.	FTP$_h$	14921	14109	b	0.232	A-IF, A-IR, TAV$_s$	0.247	- 6.9
Final(2)	FTP$_c$	15243	14432	b	0.256	A-IF, A-IR, TAV$_s$	0.308	-20.3
(7700)	FTP$_h$	15243	14432	b	0.232	A-IF, A-IR, TAV$_s$	0.247	- 6.5
Durab.	1975 FTP							-12.4
	SET	15243	14432	b	0.214	A-IF, A-IR, TAV$_s$	0.198	7.5
	FET	15243	14432	b	0.206	A-IF, A-IR, TAV$_s$	0.148	9.3

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(1) "a" designates test at normal backpressure.
"b" designates test at backpressure equivalent to that of the trap system at 80.5 km/hr (50 mph).

(2) A-IR and A-IF agglomerators removed at 12,068 km (7500 miles) of MVMA operation. Additional 4023 km (2500 miles) MVMA accumulated with factory mufflers with either TAV$_s$ or HCC swirl separators attached. Final factory system baseline obtained with 16090 km (10,000 miles) MVMA. A-IF, A-IR and TAV$_s$ reinstalled and data obtained after 322 km (200 miles) of additional MVMA obtained.

(3) Factory and particulate trap system results at start of durability test taken to be same as that obtained during evaluation. The difference of 1126 km is due to extensive laboratory operation during evaluation.

(4) Factory baseline not obtained at 4023 km (2500 miles) of MVMA operation. Used baseline obtained during evaluation.

The last part of Table 22 lists the results of the durability test. The start results were taken to be the same as that measured during the evaluation phase although substantial additional operation was made with the trap system to obtain odor and other chemical measurements. Thus, at the start of the MVMA service accumulation, the A-1R had 2853 km and the A-1F unit had 2041 km of operation. A retest was not made and it was assumed that the results were still operative and thus, the 33 percent reduction values carried over.

At 2500 miles of MVMA durability, the A-1R had 6875 km and the A-1F had 6063 km of total operation and the efficiency of the system had deteriorated to 8.2 percent by the FTP_h test. A calculated 1975 FTP value of 3.1 percent is shown at this time indicating that the A-1R and A-1F units apparently had saturated or reached equilibrium and their effectiveness as a trap had diminished substantially. This finding was not unexpected since both units have a finite interior volume and were expected to act as a trap and physically remove particulate for only a limited period.

The durability test of the A-IF, A-IR, TAV_s system was continued to 12,068 km (7500 mi) of MVMA service to investigate the potential of both A-IF and A-IR units to act as agglomerators. Only with extended operation could the A-IF and A-IR units be accurately evaluated and the possibilities of agglomeration defined. The extended service accumulation also made possible determinations of the effect of the particulate removal system on sulfate and gaseous emissions such as HC.

The 5000 mile durability test was more rigorous and involved back-to-back testing of the trap system against the factory system. These results showed about the same effectiveness of the total system as at the 2500 mile test. The 3.1 percent FTP_c, 8.8 percent FTP_h and 6.4 percent 1975 FTP results indicate that the TAV_s was, like the 2500 mile results, the major item responsible for improvement. The TAV_s will be discussed shortly.

The final inspection, made after 7500 miles of durability testing are shown on Table 22 to confirm the overall lack of a consistent reduction. Considering the 12.4 percent increase by the 1975 FTP, the 7.5 percent reduction by the SET and the 9.3 percent reduction by the FET, it is clear that the trap system continued to be ineffective in reducing particulate after sustained operation. At least, these dynamometer tests were unable to indicate an overall, consistent reduction.

The durability data on Table 22 is a condensation of the g/km listed in Appendix D as Table D-4. Table D-4 is a complete compilation of all particulate rates measured during the durability test of the A-1F, A-1R, TAV_s system with the factory system results listed for comparison. At 7500 mi of MVMA, it was decided that further operation of the entire trap system would not yield any additional information regarding system operation. Consequently, it was decided to remove the system and continue operation of the car to 10,000 mi of MVMA testing, but with the factory exhaust system plus TAV_s installed.

The promising results of the TAV_s justified additional evaluation of both the TAV_s and HCC swirl separators during the final 2500 mi segment of specific interest. The final evaluation of the A-IF, A-IR, and TAV_s was therefore delayed until the road testing was completed. Accordingly, the car had accumulated 16,090 km (10,000 mi) of MVMA, but the A-IF, A-IR, TAV_s system--12,068 km (7500 mi) of MVMA service.

On the completion of the durability testing, the final test revealed extraordinarily high particulate during the initial cold start FTP_c of 1.025 g/km versus the usual 0.3 g/km average value (Table D-4). This was discovered after the entire final series of tests was completed. After analysis of these results, it was theorized that the act of removing and reinstalling the system, including the rough treatment given the units in doing so, probably dislodged some of the particulate leading to the three times normal value of the first cold start test. It was further speculated that the approximate two week period, while the agglomerators waited for evaluation, may have resulted in "drying-out" of the particulate, cracking, flaking, or spalling of the particulate further allowing a much higher particulate emission rate than normal.

In any event, it was decided that the final test series should be re-run following a brief period of MVMA preconditioning immediately prior to the particulate testing. This was done and on 11/18/76, the final test series, at 16412 km (10,200 miles) MVMA and 14432 km A-IF and 15,243 km A-IR, was performed. It is this final test series on Table D-3, used in the Table 22 summary.

An important question is, when did the A-IF and A-IR units cease to act as traps? Since trap efficiency necessarily had to be determined at specific intervals, it is not possible from the data to state the mileage specifically. However, a reasonable estimate would place the life of the A-IF and A-IR at about 4827 km (3000 mi) total or at about 1974 km (1227 mi) into the MVMA durability test. This estimate is based in part on Figures 25 and 26 (to be discussed shortly) and the fact that the efficiency of the A-IR and A-IF units was seriously degraded at the 4023 km (2500 mi) inspection. The difference in MVMA and total mileage was due to the extensive screening and component tests as well as the emissions evaluation testing. A more important point was the finding that even though the A-IR and A-IF units ceased to act as traps, they did not plug solid and apparently continued to act as agglomerators, the original intent of the units as far as SwRI was concerned.

The fact that the Texaco alumina coated wire maze did act as an agglomerator is indicated by the continued separation of particulate by the Ethyl TAV_s unit.

2. Effects of Trap System on Gaseous Emissions

The effect of the trap system, defined as A-IF, A-IR, and TAV_s on emissions of HC, CO, NO_x, and fuel consumption/economy is summarized on Table 23. As a baseline comparison at the start of the road durability test, the gaseous emissions data obtained during the evaluation phase are relisted from Table 11. The 1975 FTP results indicate the loss in effectiveness of the A-IF, A-IR combination as a remover of unburned hydrocarbons during the course of the 12,068 km (7500 mi) of road operation. The units

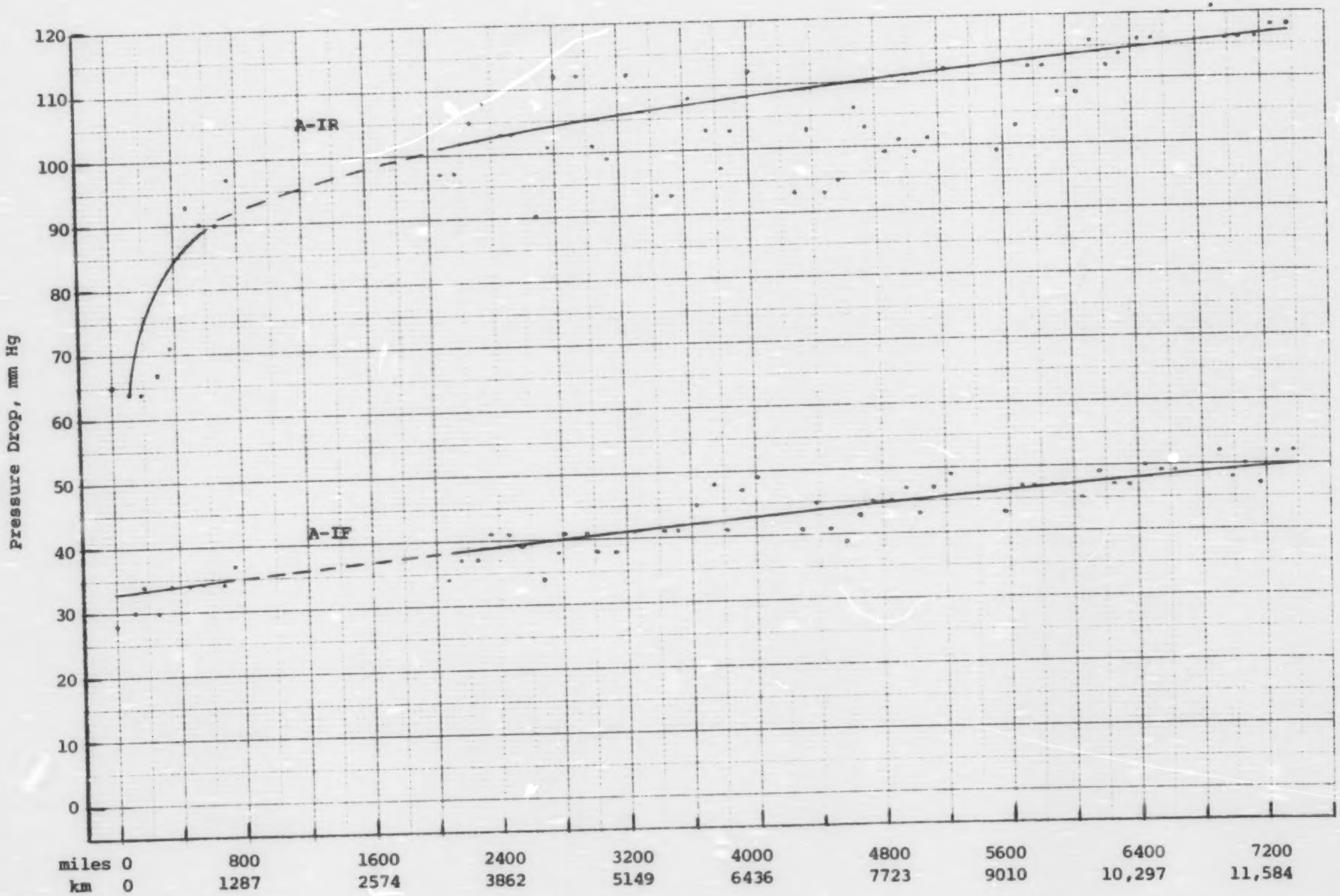

FIGURE 25. DIFFERENTIAL PRESSURES OF A-IF AND A-IR AGGLOMERATORS DURING MVMA DURABILITY TEST OF MERCEDES 300D EQUIPPED WITH A-IF, A-IR AND TAV_S SYSTEM

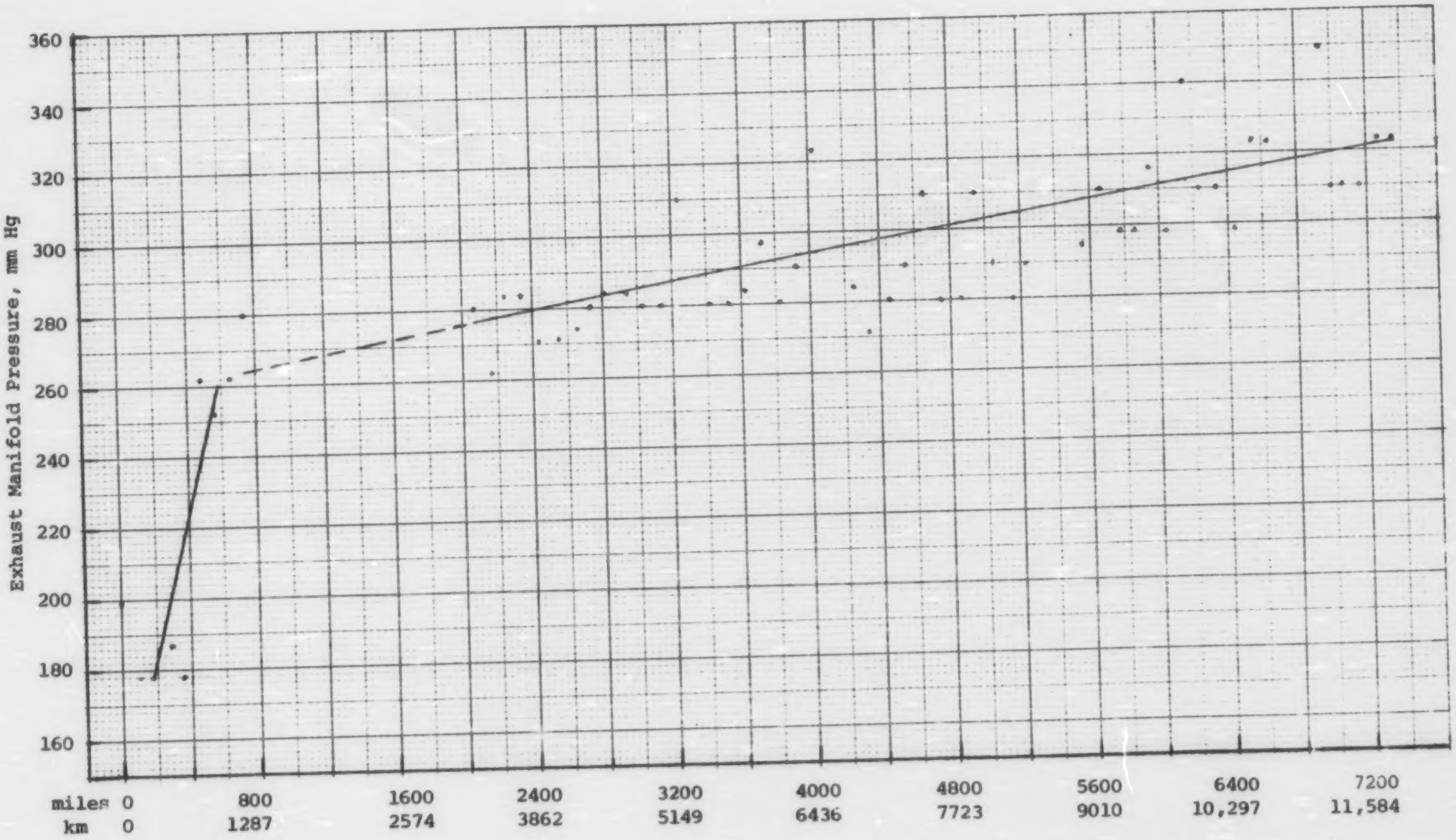

FIGURE 26. EXHAUST MANIFOLD PRESSURE AT 88.5 km/hr (55 mph) CRUISE DURING MVMA DURABILITY TEST, MERCEDES 300D EQUIPPED WITH A-IF, A-IR AND TAV_s TRAP SYSTEM

TABLE 23. GASEOUS EMISSIONS AND FUEL RATES DURING MVMA DURABILITY TEST OF PARTICULATE TRAP SYSTEM-MERCEDES 300D

Test Cycle	MVMA Test km (miles)	Test Configuration	Emission Rates, g/km			Fuel Cons. ℓ/100 km	Fuel Econ. mpg
			HC	CO	NO_x		
1975 FTP	0	Factory(1)	0.19	0.54	0.98	10.00	23.53
		Trap	0.06	0.48	0.93	9.27	25.41
	8045 (5000)	Factory(2)	0.13	0.43	0.81	8.44	27.88
		Trap	0.07	0.51	0.93	9.58	24.56
	16,090 (10,000)	Factory(2)	0.12	0.46	0.94	8.52	27.62
		Trap(4)	0.10	0.46	0.92	8.76	26.86
FTP_c	0	Factory(1)	0.21	0.55	0.99	10.30	22.83
		Trap	0.06	0.52	0.96	9.86	23.89
	16,090 (10,000)	Factory(2)	0.12	0.48	0.96	8.96	26.26
FTPh	0	Factory(1)	0.14	0.53	0.99	9.49	24.80
		Trap	0.05	0.45	0.90	8.63	27.33
	8045 (5000)	Factory(2)	0.12	0.42	0.80	8.11	29.01
		Factory(3)	0.07	0.47	0.76	8.45	27.85
	16,090 (10,000)	Factory(2)	0.11	0.46	0.88	7.99	29.45
		Factory(3)	0.06	0.35	0.84	7.99	29.45
FET	0	Factory(1)	0.07	0.34	0.88	7.79	30.23
		Trap	0.03	0.33	0.99	8.11	29.15
	8045 (5000)	Factory(2)	0.07	0.30	0.70	7.74	30.40
		Trap	0.04	0.21	0.90	8.05	29.22
	16,090 (10,000)	Factory(2)	0.05	0.32	0.81	7.11	33.09
		Trap(4)	0.06	0.32	1.00	7.09	33.19

---

(1) Average of three runs per Table 11 during evaluation at exhaust backpressure equivalent to trap system

(2) At backpressure equivalent to trap system

(3) At normal factory exhaust system backpressure

(4) Discontinued A-IF, A-IR and TAV_s trap system at 12,068 km (7500 miles) MVMA operation. Remounted system after vehicle with factory muffler and TAV_s/swirl, reached 16,090 km (10,000 miles) MVMA. Actual distance on A-IR was 15,243 km (9475 miles) and on A-IF was 14,432 km (8970 miles).

apparently continued removing HC longer than particulate, as noted by the still-low HC emissions of 0.07 g/km after 8045 km (5000 mi) of MVMA operation.

The effect of the trap system remained about the same on CO and NO_x as was found during the evaluation, namely a negligible effect. Although the data is far from consistent, fuel consumption tended to increase more times than not with the trap system bringing about a small overall decrease in fuel economy or mileage. Mingled within this effect is the variability of the basic test and the difficulty of truly matching by artificial means the exhaust backpressure imposed by the trap system when operating the factory or stock system. Accordingly, the fuel economy effect is not clear from these results. It is likely that with the increased backpressure due to the trap system, some increase in fuel consumption could occur. This effect, however, is not conclusively demonstrated by the test data.

One interesting set of experiments with the factory exhaust system was to run an extra FTP_H after the usual FTP_H but with normal backpressure. This was done during the 8045 km (5000 mile) and the 16,090 km (10,000 mi) inspections. In both instances, HC was apparently reduced some and NO_x reduced very slightly if at all with reduced backpressure. In one instance, fuel consumption was slightly greater (due ostensibly to reduced exhaust backpressure) and in one case it was unchanged. CO had a very slight increase and a slight decrease and was inconsistent. The differences thus shown are so small, except HC, as to be considered negligible thus lending credence to the previous finding that the trap system effects on fuel consumption are probably not due to increased backpressure, but are in fact experimental variation.

The computer sheets that provide additional detail are included in Appendix E as Tables E-26 to E-31 for the 8045 km (5000 mile) inspection and as Tables E-32 to E-38 for the 16,090 km (10,000 mi) inspection.

3. Effect of Trap System on Sulfate

During the evaluation phase of this project, it was found that the trap system,principally the A-1F and A-1R agglomerators resulted in the collection of approximately 90 percent of the sulfuric acid mist (sulfate) emissions. Although it was known that the agglomerators deteriorated in terms of particulate trapping efficiency prior to accumulation of 4023 km (2500 miles) of MVMA driving, the removal of sulfate was of interest after 12068 km (7500 miles) of MVMA operation.

Table D-5 of Appendix D is a listing of the sulfate emission test (SET) results after 14,109 km (8769 miles) of A-1F and 14,921 km (9273 miles) of operation on A-1R. The factory system, at exhaust backpressure equivalent to the trap system, resulted in 12.601 mg/km of sulfate. This compares fairly well with that measured during the evaluation of 11.7 mg/km. The trap system resulted in an average of 5.174 g/km during the final evaluation and then 5.265 mg/km during the re-run of the final test. Recall the final test, after 12,389 km (7700 miles) was a re-run of the 12,068 km (7500 miles) of MVMA trap operation because of the abnormally high cold start particulate. The problem of abnormal and unrepeatable particulate was not experienced with the sulfate measurements.

Using an average of 5.220 mg/km for the trap, this represents a 58.5 percent reduction. The sulfate trapping is not as good as that measured during the evaluation some 12,068 (7500 mi) earlier (93.4 percent), but it is apparent that the agglomerators continue to trap and remove sulfuric acid mist from the exhaust. This is a very interesting and possibly important finding. Even though the alumina coated steel wool of the A-IF and A-IR reached a loaded or equilibrium state with respect to exhaust particulate much earlier, the traps have apparently continued to be effective, though substantially less, in collected sulfate.

Although sulfate (sulfuric acid aerosol) acts as a particulate and can be collected on a 0.5 micron filter, it also adsorbs on and within the tremendous surface area of the fired alumina. The sulfate will enter and apparently be retained, by the alumina coating crystal structure even though carbon and carbonaceous particulate are not collected. The specific collection mechanism is not fully understood nor is the form of the sulfate, once collected. More importantly, it is not known what the purge or storage-purge cycle of the fired alumina is in this system.

The potential of the alumina coated steel wool material for removal of sulfate has not been fully evaluated. Although it would be best to reduce sulfate production, for example, in a gasoline powered car by combustion and catalyst control, the simple trapping of sulfate might be of some benefit, assuming the material once collected would not be purged during certain types of driving.

One final comment on the data on Table D-5 is with regard to the experiment made with the factory exhaust system at equivalent 80.5 km/hr (50 mph) exhaust backpressure and at normal backpressure. The results of these two single SET tests, made on 11/2/76 and on 11/3/76 indicate the higher backpressure gave higher sulfate emissions, 12.607 versus 9.916 mg/km. The difference in backpressure was about 29.2 cm (11.5 in. Hg). It is difficult to attribute higher sulfate emissions to higher exhaust backpressure on the basis of this single test. Possibly some purge of sulfate may have occurred on the first day of running although this is not certain. In any event, it would be interesting to investigate this in some future program.

4. Effect of Trap System on Engine Exhaust Backpressure

Table H-1 of Appendix H lists the exhaust system backpressures measured at approximately 160 km (100 mile) intervals during the 16090 km (10,000 mile) MVMA operation. Actually, six different exhaust system configurations were operated during the course of the MVMA operation. Most of the readings were taken with the A-1F, A-1R, TAV_S combination since it was tested for 12,068 km (7500 mi) of the 16,090 km (10,000 miles) covered by the road test.

In order to obtain an overall trend of the increase in component pressure differentials and overall system backpressures, the results are plotted on Figures 25 and 26. The gap in the graphs between 1272 and 3353 km was during the time the TAV_S was replaced by the HCC swirl separator to investigate its potential and to see how much reduction in backpressure the swirl tube would allow. Accordingly, the graph is shown by a broken line in this region.

Figure 25 shows the pressure drop across the front unit, the A-1F (lower curve) and the rear unit, the A-1R (upper curve) as a function of distance. The pressure drops across both units increased with time, especially the rear unit where most of the system efficiency was achieved.

Overall, the pressure drop across the rear agglomerator doubled from 66 to 132 mm Hg (2.6 to 5.2 in. Hg) at 55 mph cruise (during lap 10 of the MVMA road cycle. The pressure increase due to the front or A-1F agglomerator was almost double, from 30 to 53 mm Hg (1.2 to 2.1 in. Hg). It is interesting to note the "knee" in the curve of the rear agglomerator occurred at about 2000 km (1243 miles) into the MVMA testing which coincides with the time at which the trap system reached equilibrium and its efficiency deteriorated to the point where the A-IR (and A-IF) began to presumably act as agglomerators and not as collectors of the particulate.

Figure 26, a graph of the exhaust manifold backpressure imposed by the trap system, shows a similar trend. The "knee" of the curve occurred earlier than that shown by Figure 25 but still is consistent with the estimated time at which the agglomerators were no longer traps and collectors. Note that the pressure at the exhaust manifold increased rapidly and essentially doubled during the course of the experiment.

The data points on both Figures 25 and 26 are not as consistent and uniform as one would expect. It should be remembered that during lap 10, the high speed cruise, the driver reads the several static and differential pressure gage indications into a tape recorder noting the date, mileage, and time of day.

Some of the scatter is no doubt due to the method of data taking and influenced somewhat by road, wind and other operating conditions. It also may be possible that part of the scatter is real and due to possible build-up of particulate in the system prior to purge. It may be possible that the mechanism of agglomerator action was one of partial build-up and then, due to increased backpressure a partial purge and then the process repeated itself.

At the conclusion of the MVMA operation, the pressures were carefully obtained by two technicians over lap 10, the high speed lap. These values, for the factory exhaust systems with and without the swirl separator are listed at the bottom of Table H-1.

At the conclusion of each dynamometer evaluation, pressures were obtained at various steady-state cruise conditions. Table 24 lists these results. Regrettably, not all pressures were measured at the start of the test. Selected measurements were taken with the factory exhaust system at the conclusion of the test. These are listed on Table 24 for direct comparison with the trap system pressures taken then and at earlier intervals.

In addition to this discussion of the increased, essentially doubled, exhaust system pressures during the MVMA cycle durability test,

TABLE 24. DYNAMOMETER EXHAUST SYSTEM PRESSURES - MERCEDES 300D WITH AND WITHOUT TRAP SYSTEM INSTALLED

			Exhaust System Pressures, mm Hg						
				Front Muf/Trap		Rear Muf/Trap		ΔP(1)	ΔP(2)
Speed km/hr	Test km	Test Conf.	Manif.	In	Out	In	Out	Front	Rear
0	0	Trap		15		10	2		
(0)(3)	4023	Trap	23	23	17	15	4	6	13
	8045	Trap	26	20	19	17	2	7	11
	12068	Trap	22	19	11	11	2	7	9
	12068	Fact(4)	9	6	6	6	6	0	0
	12068	Fact(5)	0	0	0	0	0	0	0
16.1	0	Trap		51		41	17		
(10)	4023	Trap	64	66	47	47	20	13	26
	8045	Trap	69	64	49	47	22	15	22
	12068	Trap	67	65	49	47	19	17	26
	12068	Fact(4)	47	37	37	37	37	0	0
	12068	Fact(5)	9	0	0	0	0	0	0
32.2	0	Trap		74		56	26		
(20)	4023	Trap	104	102	73	67	34	19	37
	8045	Trap	103	93	75	75	37	22	36
	12068	Trap	99	93	75	71	32	22	36
	12068	Fact(4)	75	65	65	62	62	0	0
	12068	Fact(5)	9	4	4	0	0	0	0
48.3	0	Trap		79		61	28		
(30)	4023	Trap	109	106	80	77	39	20	41
	8045	Trap	112	105	84	80	39	24	39
	12068	Trap	108	105	82	78	34	26	43
	12068	Fact(4)	129	75	75	70	65	0	4
	12068	Fact(5)	15	6	6	0	0	0	0
67.6	0	Trap		132		107	52		
(40)	4023	Trap	183	178	142	138	75	28	65
	8045	Trap	179	168	148	140	75	34	65
	12068	Trap	181	179	144	140	65	36	73
	12068	Fact(4)	150	140	140	135	135	0	0
	12068	Fact(5)	22	15	15	4	4	4	0
80.5	0	Trap		193		160	86		
(50)	4023	Trap	282	273	234	224	121	37	97
	8045	Trap	277	277	235	228	121	43	99
	12068	Trap	280	278	235	224	112	48	108
	12068	Fact(4)	271	267	261	252	247	4	3
	12068	Fact(5)	37	22	19	8	8	4	0
96.5	0	Trap		259		221	123		
(60)	4023	Trap	386	373	350	340	185	45	127
	8045	Trap	394	384	353	348	185	50	136
	12068	Trap	396	391	357	340	168	57	151
	12068	Fact(4)	379	376	363	361	361	6	0
	12068	Fact(5)	56	37	32	15	9	8	0

---

(1) Pressure drop across Texaco A-1F or factory front muffler.

(2) Pressure drop across Texaco A-1R or factory rear muffler.

(3) mph

(4) At increased backpressure set to 150 mmHg at 80.5 km/hr (50 mph).

(5) At normal backpressure.

the exhaust system pressures are clearly too high to be commercially acceptable. In order to prove the principal of the trap system, the durability test was performed even though the backpressure was considered excessive at the start and unacceptable at the end of the test. It is expected that to remove particulate, the gas must work and therefore experience a pressure drop. In this case, the pressure drops and system backpressure are considered unacceptably high.

Estimates were made of which item contributed the most restriction or backpressure on the engine. The three major elements of the system and their order of effectiveness were the A-IR rear agglomerator (about 40 percent), the TAV_S separator (about 35 percent), and the front muffler (about 15 percent). While the A-IF and A-IR units experience a steady linear increase in pressure drop, the TAV_S imposed about 135 mm Hg (5.3 in Hg) while the HCC swirl separator imposed about 81 mm Hg (3.2 in Hg) at 80.5 km/hr (50 mph) cruise.

5. Effect of Separators on Particulate Collection

As indicated by the screening tests, the TAV_S was more effective than the HCC swirl separator even though the TAV_S imposed a higher backpressure. What the dynamometer screening tests did not predict was the somewhat surprising amount of particulate collected by both when operating in conjunction with the A-IF, A-IR agglomerator combination or even when connected to the usual factory system.

Figure 27 shows what was found the first time the TAV_S was opened and particulate was found. The upper left view shows the disassembled TAV_S and the upper right view the amount of particulate dumped out of the TAV_S from both entry (or swirl) end as well as the trap (or collector) and after 981 km (610 miles).

Although most of the material could be "dumped-out", some remained as shown by the center left photo as a "cake", or layer on the interior walls of the separator. This material had to be scraped out. The pile of wire squares in the center left and two lower photos is the chopped lath that is packed into both ends of the separator. These act to prevent re-entrainment of the collected particulate.

The consistency of the particulate is indicated some by the left center and lower left views. It was flour-like in handling characteristics, very fine, dry and powdery and difficult to handle and keep from becoming airborne. The fine powder nature of the particulate lacked the greasy or sticky nature of some diesel exhaust particulate.

The HCC swirl tube separator is shown by the two top photos of Figure 28 as installed on the Mercedes 300D instead of the Ethyl TAV_S. Note that the exhaust is turned up from the conical outlet of the A-IR, under the bumper, and then directed vertically up through the swirl tube. The lower left view shows the steel mesh cloth used to pack the collection cavity and prevent re-entrainment of the particulate.

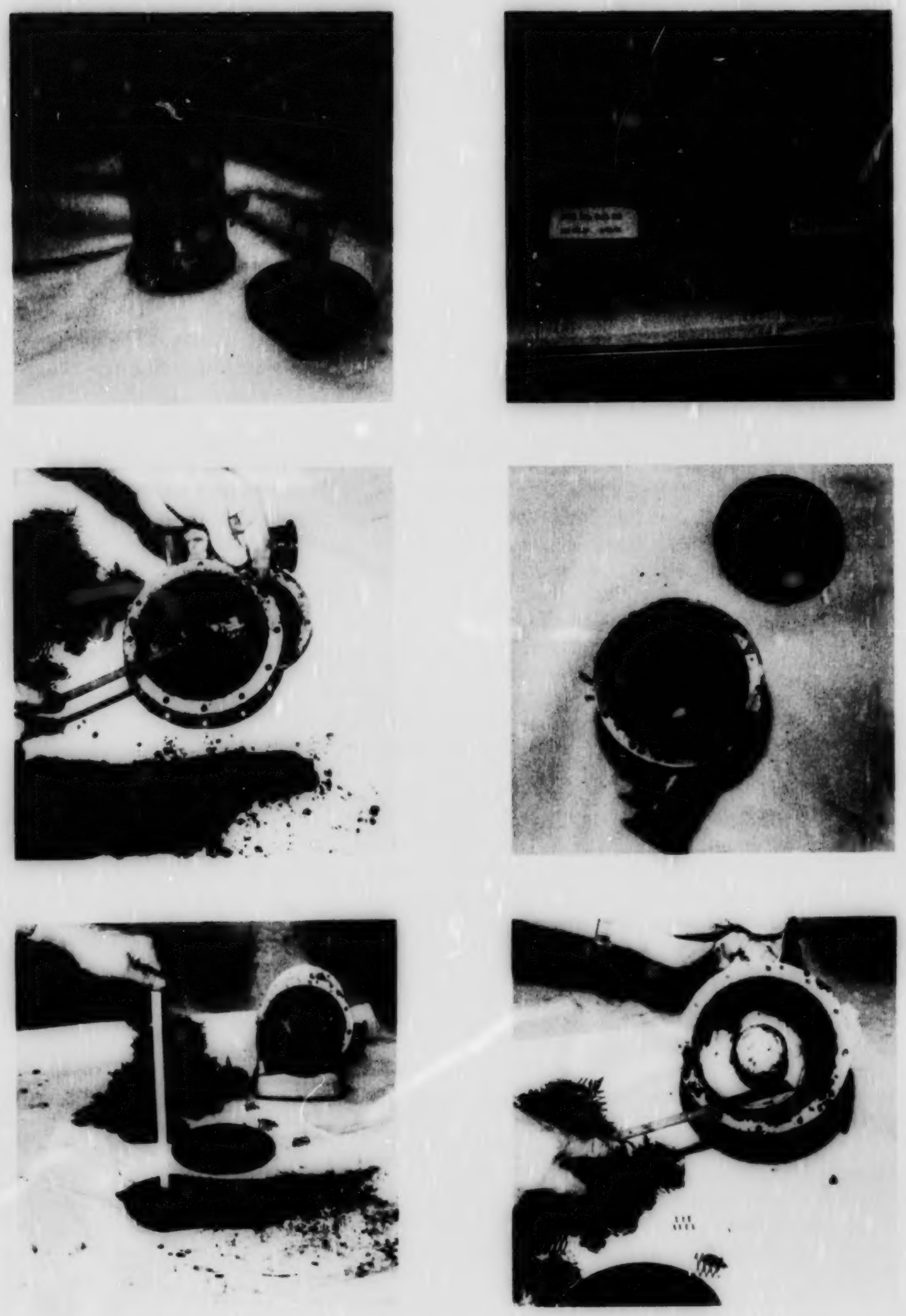

FIGURE 27. DIESEL EXHAUST PARTICULATE COLLECTED BY THE ETHYL TAV_S SEPARATOR

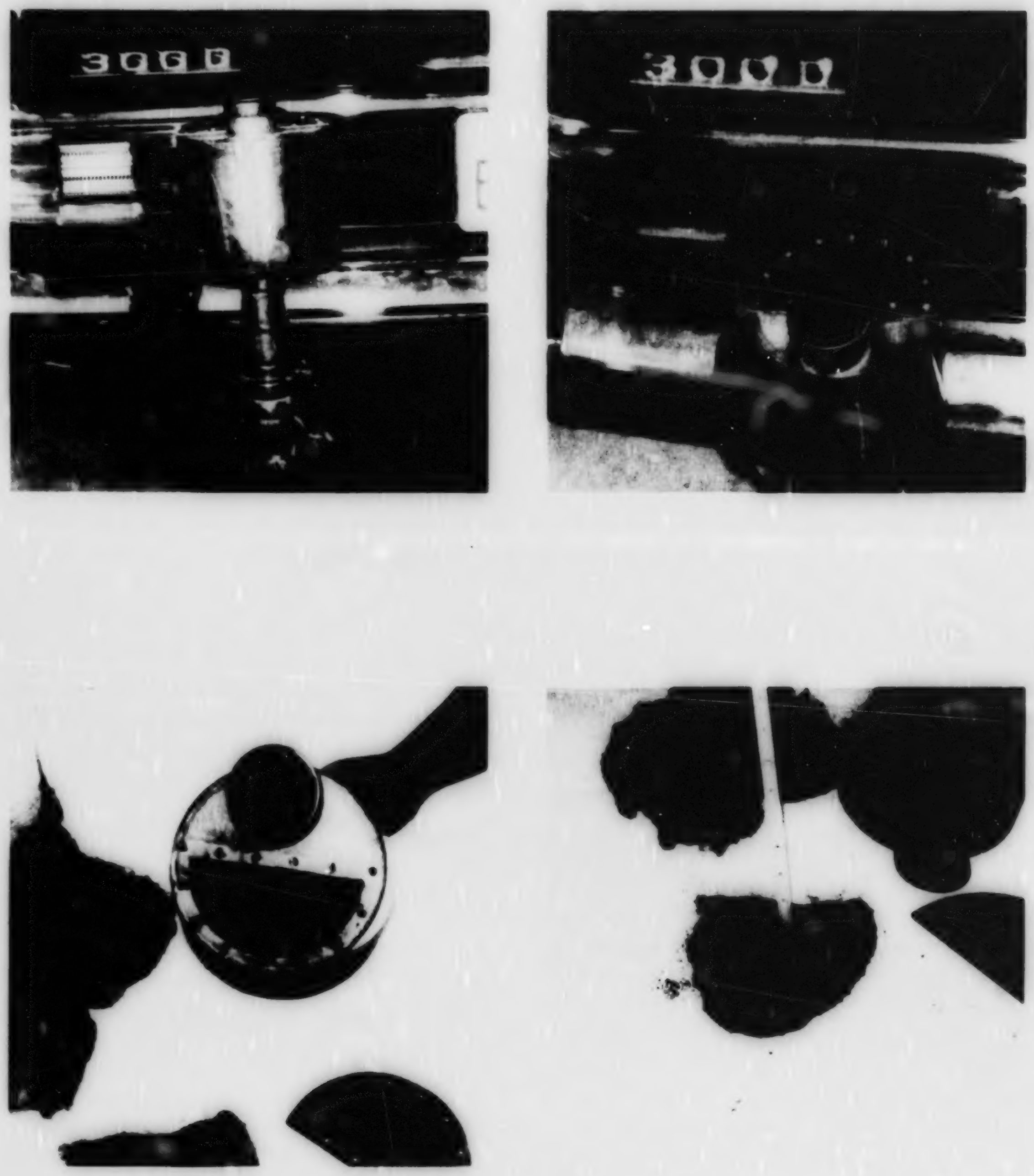

FIGURE 28. DIESEL EXHAUST PARTICULATE COLLECTED BY THE HCC SWIRL TUBE SEPARATOR

The lower right view illustrates the type of particulate collected by this separator in conjunction with the A-IF and A-IR units. The appearance and consistency of the collected particulate was somewhat different from that found in the TAV_s. The swirl collected particulate was, to a great extent, shaped in tiny spheres. These spheres were possibly formed by the swirl or rotational action of the device. In any event, the matter collected was somewhat encouraging.

Table 25 is a complete listing of the weights and volumes of the particulate collected by the TAV_s or swirl separators at various intervals of MVMA test distance. In addition, Table 25 lists the incremental distance traveled for each quantity of particulate collected permitting calculation of incremental and average collection rates in terms of mg/km and cm^3/km. The quantities thus collected permitted bulk density determination by dividing the mass by the volume to give a g/cm^3 density value.

Listed first on Table 25 are the TAVs results of 13.45 mg/km during the first 1255 km (780 miles) of MVMA. During the last 5,000 miles of operation from 4172 to 11551 km (2593 to 7179 miles) the average collection rate was 5.79 mg/km. During these same intervals, the volume collection rate changed but very slightly from 0.208 to 0.178 cm^3/km. Of importance, the bulk density was much higher at first 0.066 g/cm^3 and then much lower at the end of the test, 0.034 g/cm^3.

Apparently, the type of agglomerates exiting the AI-R changed such that the resulting density of the material collected was half that at the start. It is uncertain when the particulate became half as dense as that at the start, but quite likely the change was associated with the A-IF and A-IR "loading-up" and reaching equilibrium at about 2000 km (1243 miles) of MVMA operation.

The HCC swirl separator collected at the rate of 3.72 mg/km when connected to the A-IF, A-IR system. This is substantially less than the 13.45 mg/km with the TAV_s. It may be best to compare the swirl to the TAV_s collection rate during the last part of the test of 5.79 mg/km. The density of 0.028 was essentially the same as the 0.034 g/cm^3 of the TAV_s at the end of the test. These results tend to confirm that the A-IR reached equilibrium at about 2000 km (1243 miles) of the MVMA test.

Listed at the bottom of Table 25 are the results of the TAV_s and swirl, in conjunction with the factory system. These experiments were made during the final 4023 km (2500 miles) of the test and revealed that not only were both high pressure drop inertial separators able to collect some of the exhaust particulate from a standard Mercedes 300D diesel car, but the bulk densities were on the order of ten times heavier than the densities from the trap system.

Note that the TAV_s average collection rate was 20.04 mg/km versus 5.79 mg/km. The two test increments resulted in greatly different rates in terms of mg/km and cm^3/km. If the initial collection interval were discounted due to possible discharge of metallic or related muffler materials, the 10.62 mg/km with the TAV_s is not grossly different than the 12.27 mg/km

TABLE 25. PARTICULATE COLLECTED BY TAV$_S$ OR HCC SWIRL SEPARATORS DURING MVMA DISTANCE ACCUMULATION

MVMA Distance		Incremental Distance		Amount Collected	Volume Collected	Collection Rate		Bulk Density,
km	miles	km	miles	grams	cm^3	mg/km	cm^3/km	g/cm^3
				A-IF, A-IR and TAV$_S$				
924	574	923	574	13.49	175	14.615	0.189	0.077
1255	780	331	206	4.07	75	12.290	0.226	0.054
Average						13.452	0.208	0.066
				A-IF, A-IR and HCC Swirl				
1958	1217	626	389	2.10	68	3.354	0.108	0.031
3173	1972	1215	755	4.97	200	4.090	0.165	0.025
Average						3.722	0.136	0.028
				A-IF, A-IR and TAV$_S$				
4172	3593	981	610	6.70	240	6.829	0.245	0.028
5223	3246	1051	653	6.47	200	6.156	0.190	0.032
6574	4086	1239	770	6.46	225	5.213	0.182	0.029
8418	5232	1657	1030	9.26	300	5.588	0.181	0.031
10362	6440	1818	1130	11.00	250	6.050	0.138	0.044
11551	7179	1223	760	6.0	160	4.906	0.131	0.038
Average						5.790	0.178	0.034
				Factory Stock and TAV$_S$				
13139	8166(1)	1200	746	35.35	75	29.458	0.062	0.471
14328	8905(2)	1036	644	11.00	40	10.618	0.039	0.275
Average						20.038	0.050	0.373
				Factory Stock and HCC Swirl				
16006	9948	1527	949	18.74	90	12.27	0.059	0.208

---

(1) Several large hard particles in the deposits

(2) Approximately 483 km (300 miles) with low backpressure, due to broken clamp before first muffler

with the HCC swirl separator. In any event, the material thus collected was much more dense than that collected by the TAV or swirl when used with the Texaco alumina coated agglomerators.

6. Discussion

Based on an average 1975 FTP particulate emission rate of 0.312 g/km for the factory standard exhaust equipped Mercedes 300D, a total of 25.1 kg (55.3 lbs) of particulate would be exhausted in 80,450 km (50,000 miles). If the entire 25.1 kg had 0.066 g/cm^3, then a container with 380 litres (13.4 ft^3 or 100 gallons) volume would be needed. If only half were actually collected, then about 50 gallons of particulate would have to be stored unless more frequently removed than on 80,450 km (50,000 mile) intervals.

If half the particulate were collected based on a bulk density of 0.034 g/cm^3, then 369 litres, about the same volume, would be collected as in the previous case based on 0.066 g/cm^3 density for total collection. These volumes of particulate are quite large and represent the ranges of volumes necessary over 80,450 km (50,000 miles) of driving.

Assuming a separator such as TAV$_s$ were perfected for use with factory exhaust system, then, using 0.373 g/cm^3 density, the volume of particulate, if say one-fourth of the particulate could actually be collected, would be 16.8 litres, about 4.4 gallons. The likelihood of this density of particulate and one-fourth of the total collectable by an inertial separator has not been demonstrated. If, however, the average rate of collection by the TAV$_s$ of 20.04 mg/km were obtained during the 80450 km, then the mass collected would be 1.612 kg, or about 6 percent of the mass of particulate exhausted. The 1.612 kg would require a collection volume of approximately 4.32 litres (1.14 gallons). This is manageable and possible with some trouble and at the increase in exhaust backpressure at 88.5 km/hr (55 mph) of 57 mm Hg (2.24 in. Hg), from 23 for the stock system to 80 mm Hg at the engine exhaust manifold.

This increase in backpressure could possibly be reduced some without reduction in collection efficiency through design changes. In fact, it is not certain whether improvements in collection efficiency might not be obtained through advanced design and development of the TAV$_s$ or a similar high pressure drop inertial separator. In summary, it could be possible to achieve some measure of collection with inertial separation, a device that is relatively rugged, reliable, and not prone to changes in pressure drop, plugging, or deterioration. A 10 percent reduction in particulate, however, seems below that necessary to justify the expense to design, develop and fabricate such a separator for diesel-powered cars.

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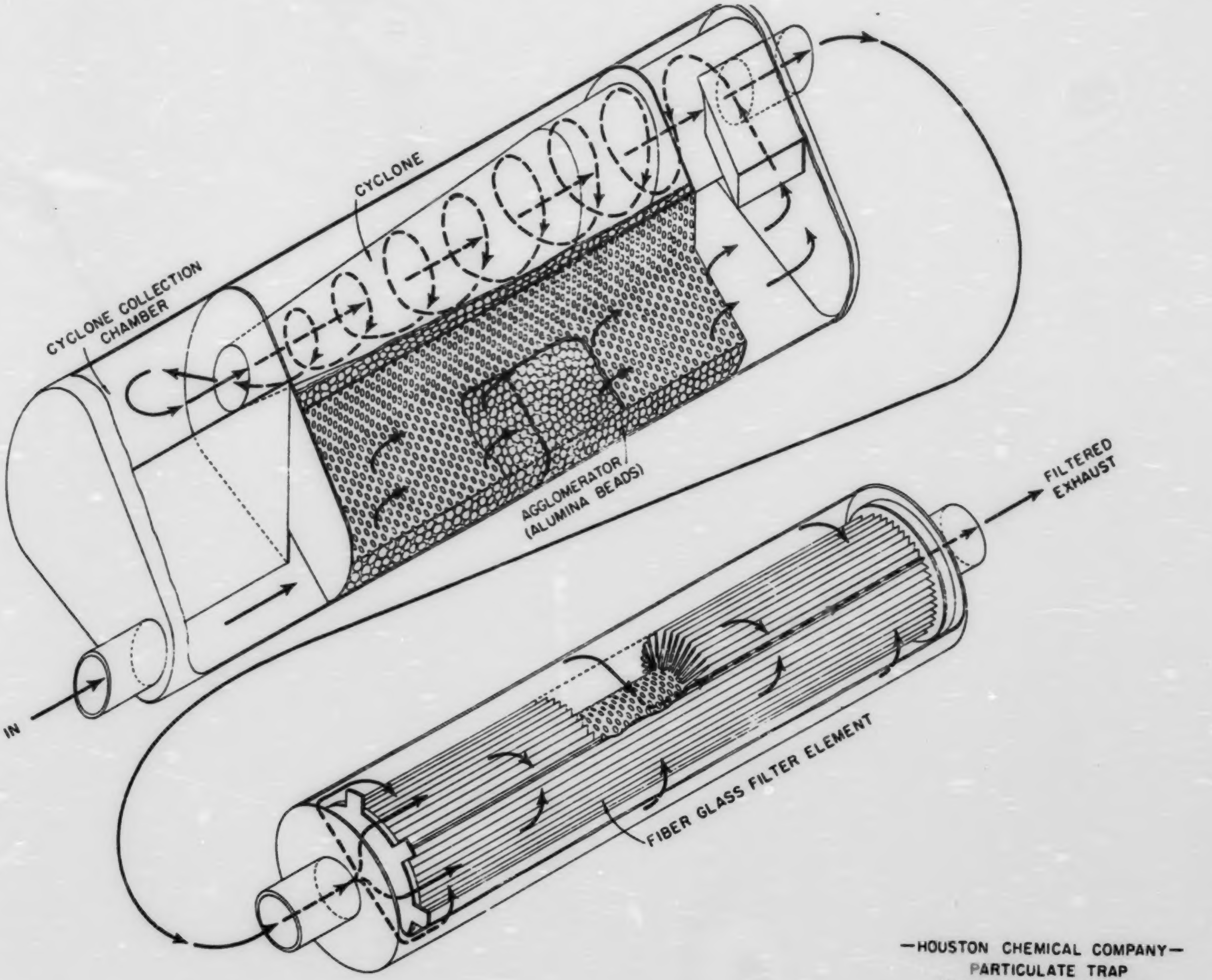
APPENDIX A

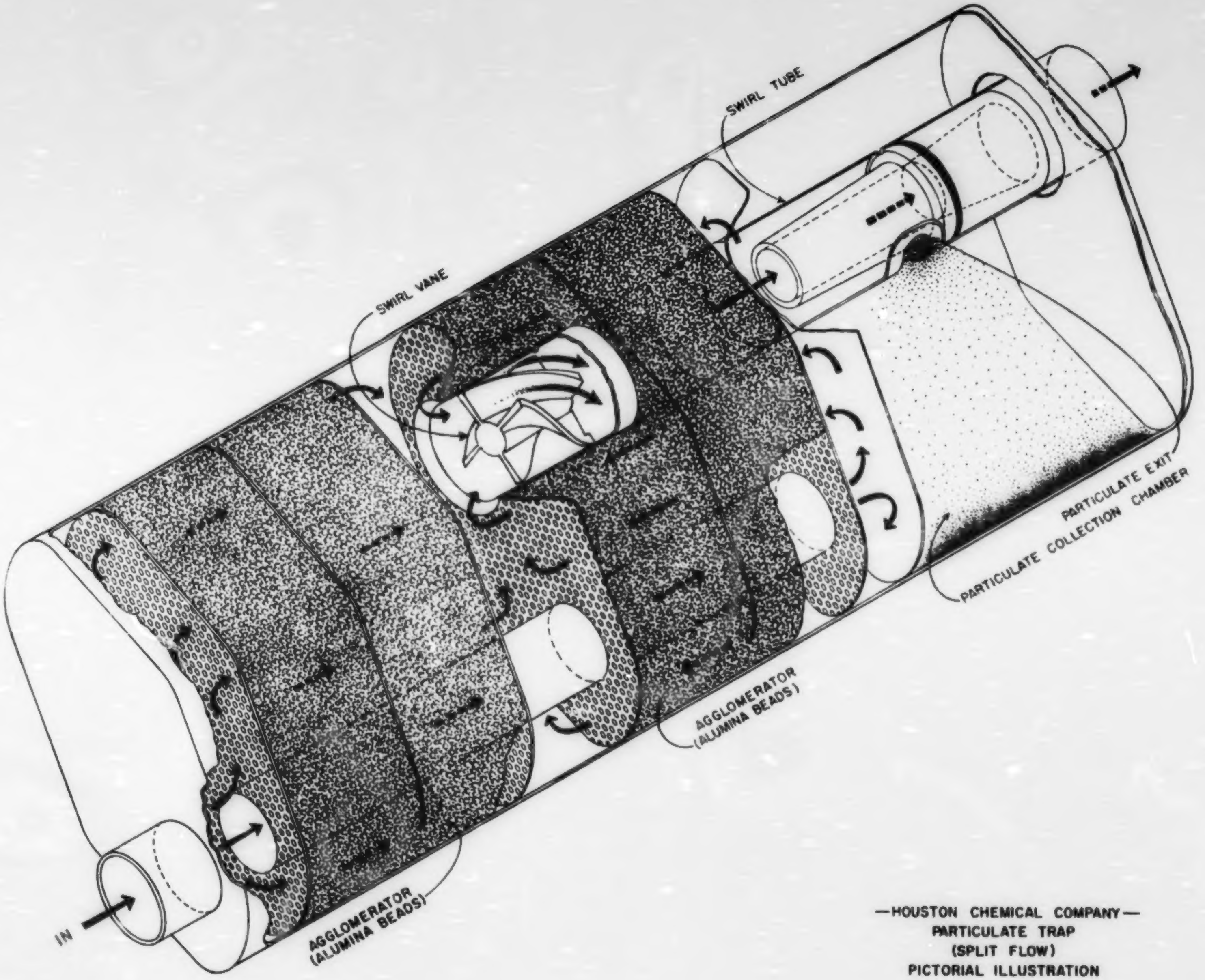
PICTORIAL ILLUSTRATIONS AND SCHEMATIC DRAWINGS OF LEAD PARTICULATE TRAPS


CYCLONE COLLECTION CHAMBER
CYCLONE
AGGLOMERATOR (ALUMINA BEADS)
IN
FILTERED EXHAUST
FIBER GLASS FILTER ELEMENT

—HOUSTON CHEMICAL COMPANY—
PARTICULATE TRAP
PICTORIAL ILLUSTRATION

6-29-73

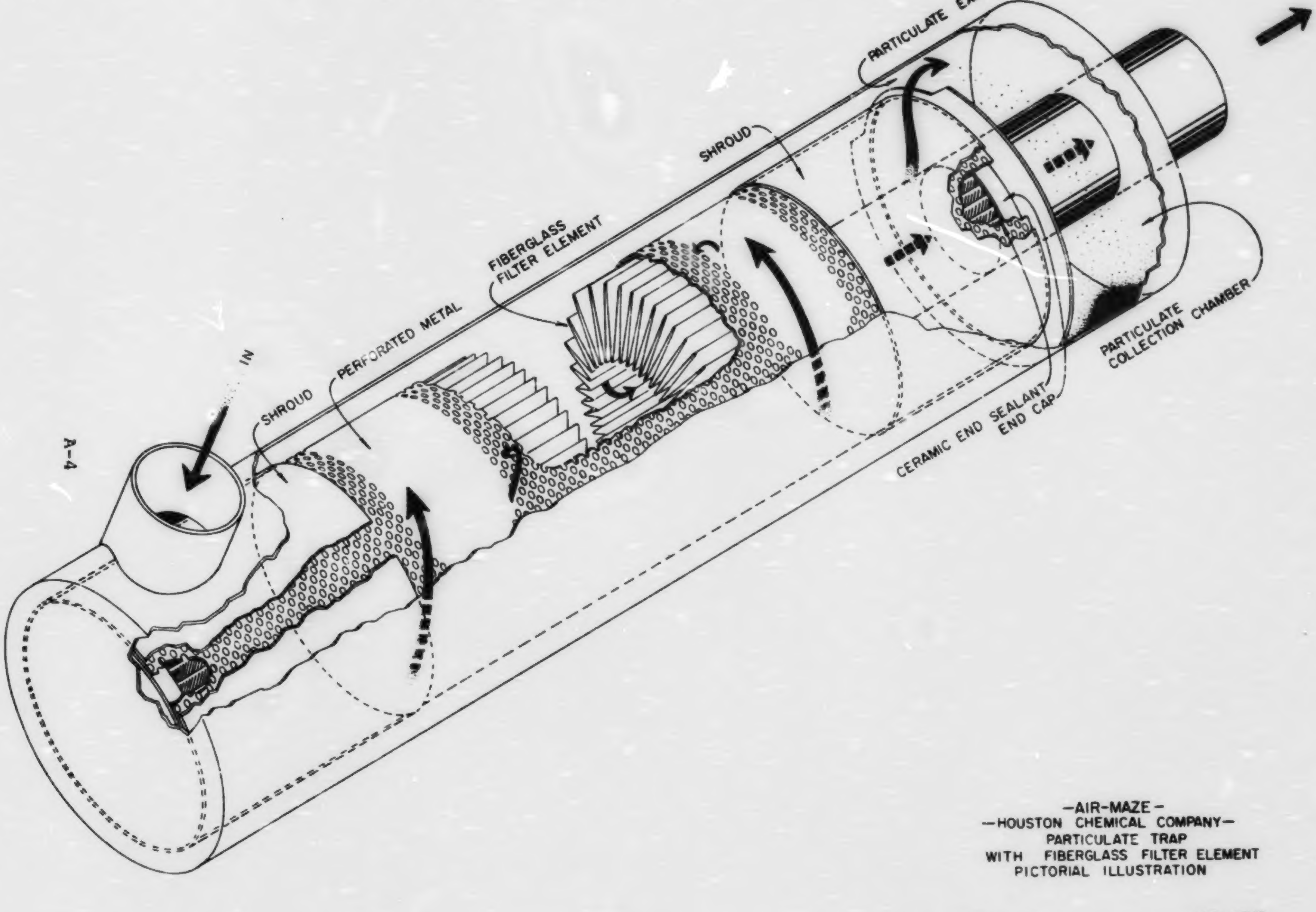
HC-115
(HCC-115)


SWIRL TUBE
SWIRL VANE
PARTICULATE EXIT
PARTICULATE COLLECTION CHAMBER
AGGLOMERATOR
(ALUMINA BEADS)
AGGLOMERATOR
(ALUMINA BEADS)
IN

—HOUSTON CHEMICAL COMPANY—
PARTICULATE TRAP
(SPLIT FLOW)
PICTORIAL ILLUSTRATION

2-20-74

HC-125
(HCC-125)
J.Mc

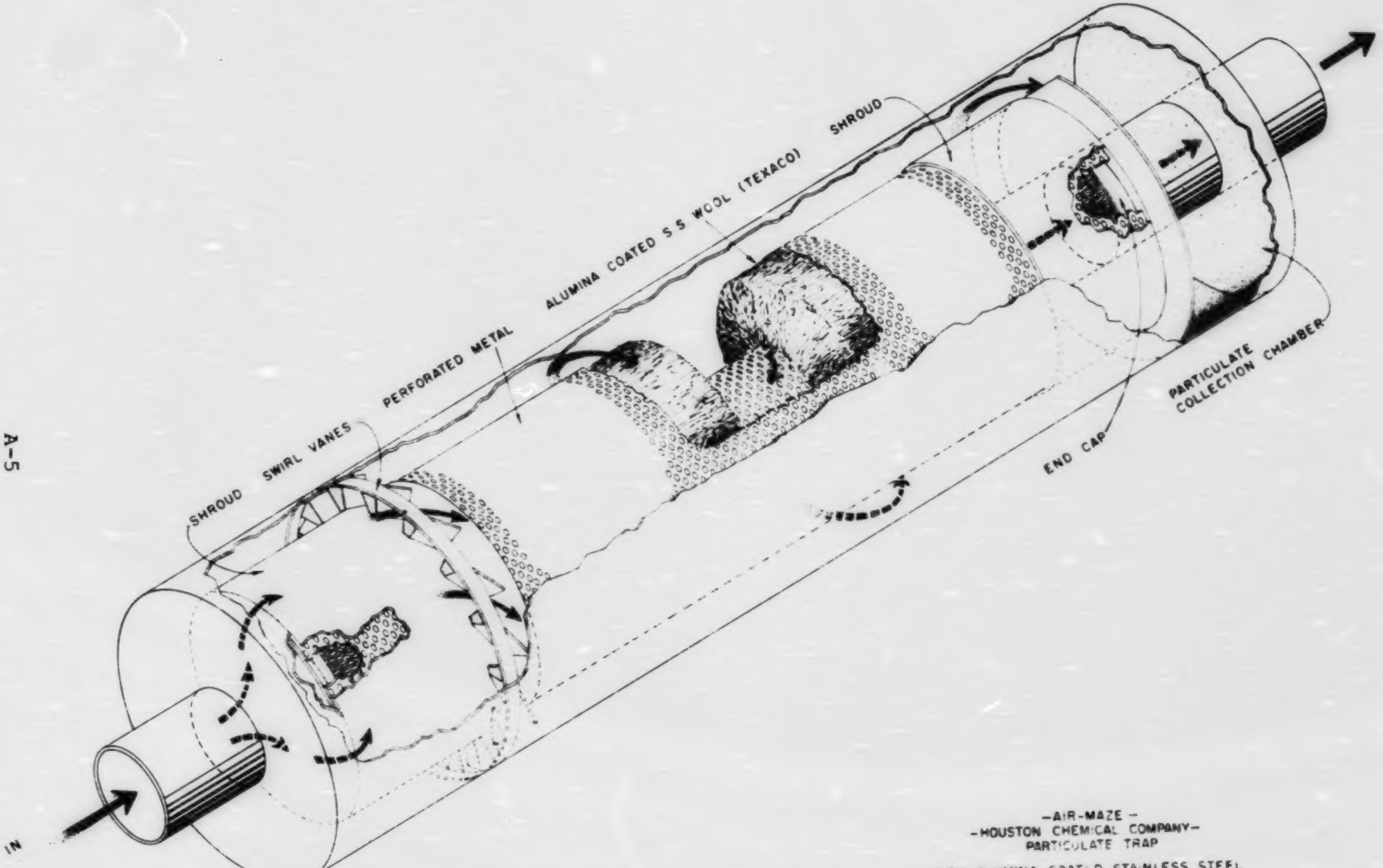

IN
SHROUD
PERFORATED METAL
FIBERGLASS
FILTER ELEMENT
SHROUD
PARTICULATE EXIT
CERAMIC END SEALANT
END CAP
PARTICULATE
COLLECTION CHAMBER

-AIR-MAZE-
--HOUSTON CHEMICAL COMPANY--
PARTICULATE TRAP
WITH FIBERGLASS FILTER ELEMENT
PICTORIAL ILLUSTRATION

4-19-74

HC-127
(HCC-127)

J MC CLELLAND



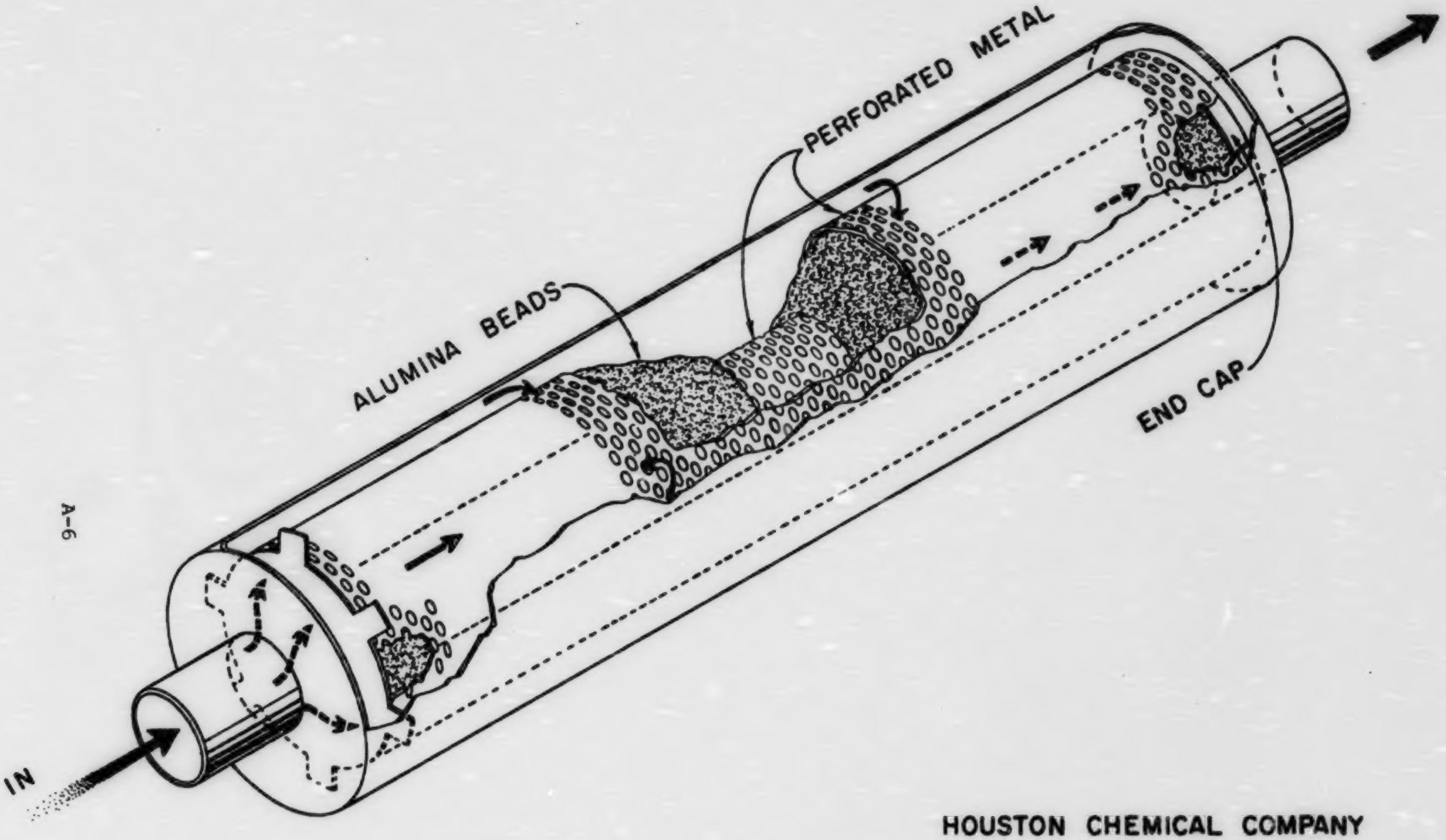
SHROUD
SWIRL VANES
PERFORATED METAL
ALUMINA COATED S.S. WOOL (TEXACO)
SHROUD
END CAP
PARTICULATE COLLECTION CHAMBER
IN

-AIR-MAZE -
-HOUSTON CHEMICAL COMPANY-
PARTICULATE TRAP

WITH ALUMINA COATED STAINLESS STEEL
WOOL FILTER ELEMENT

8-27-74

HC-130
(HCC-130)

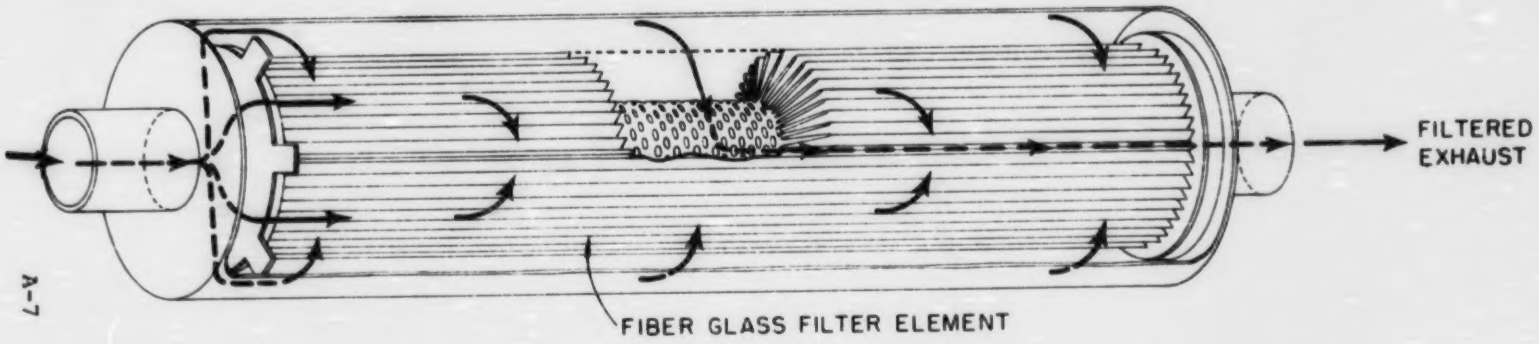

ALUMINA BEADS
PERFORATED METAL
END CAP
IN

HOUSTON CHEMICAL COMPANY

ALUMINA BEADS FILTER ELEMENT

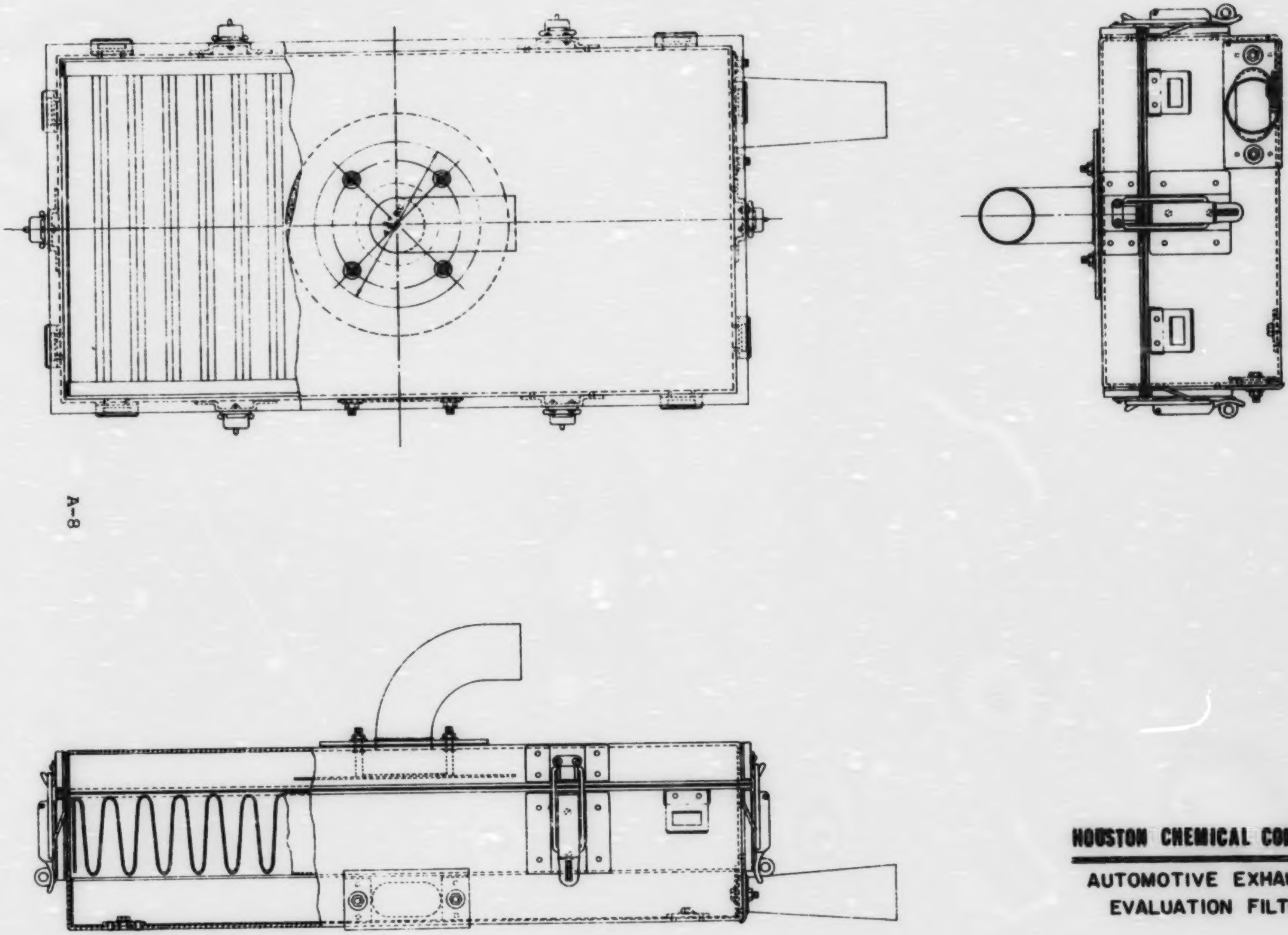
11-22-74

HC 137
(HCC-137)


FILTERED EXHAUST
FIBER GLASS FILTER ELEMENT

—HOUSTON CHEMICAL COMPANY—
PARTICULATE FILTER

1-15-73



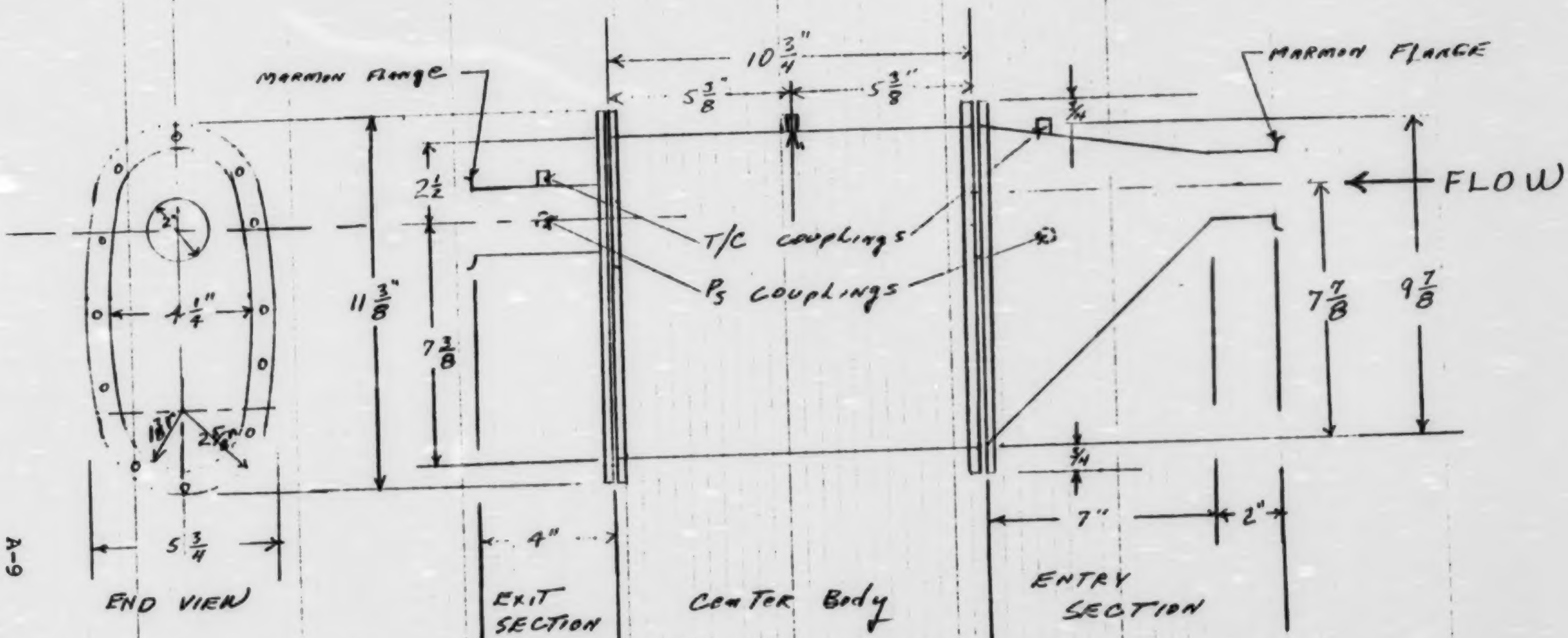
HOUSTON CHEMICAL COMPANY

AUTOMOTIVE EXHAUST
EVALUATION FILTER

10-23-72

FRONT Muffler - MERCEDES 300 D

[illegible]
[illegible]
[illegible] Springer


MARMON Flange
MARMON FLANGE
FLOW
10 3/4"
5 3/8"
5 3/8"
3/4
3/4
2 1/2
7 3/8
11 3/8"
7 7/8
9 7/8
T/C couplings
P_s couplings
2"
4 1/4"
5 3/4
4"
7"
2"
END VIEW
EXIT SECTION
CENTER Body
ENTRY SECTION

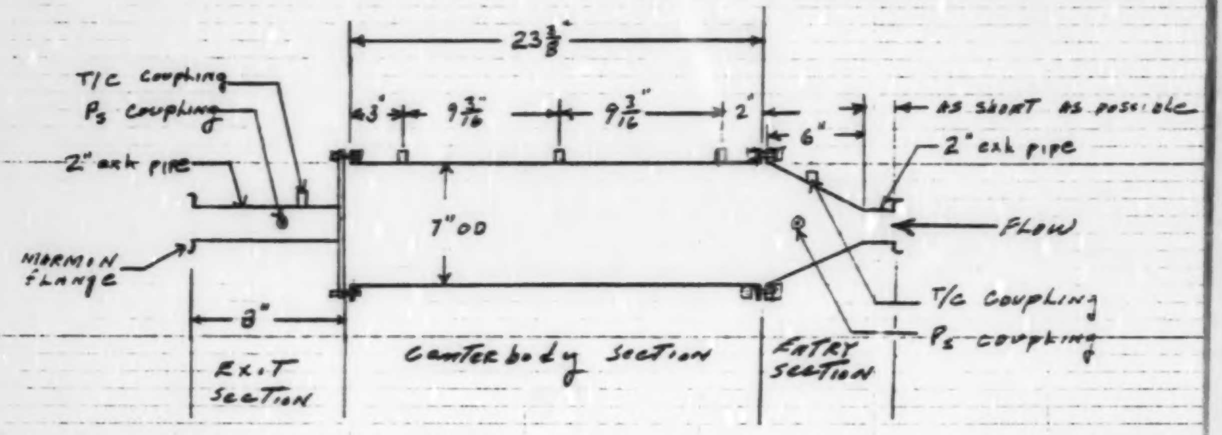
NoTes

1. Make 3 ea Centerbodies of stainless (16 gage 316) with mild steel end flanges, 1/4" thick slip over stainless oval and heliarc. Flanges to be 3/4" wide for gasket of 3/32 or 1/8" thick Asbestos. Flanges should be drilled through for 1/4" bolts, 12 at equally spaced intervals. After welding, true up mating surfaces for leak tight fit.

2. Make 1ea entry section from mild steel to transition from existing nominal 2" exhaust to oval cross section of center body. Option of weld to existing 2" exhaust or use Marmon clamp. Can remove exhaust pipe at entry to section as req'd.

3. Make 1ea exit section from mild steel to transition from oval centerbody to 2" exhaust. Weld on Marmon flange for coupling with existing pipe.

4. Note location of T/C and P_s fittings. Fittings can be 1/4" pipe half couplings of either stainless or steel. Drill through (center) for 1/4" T/C and for static pressure tap openings.



23 3/8"
T/C coupling
P_s coupling
3"
9 3/16"
9 3/16"
2"
AS SHORT AS POSSIBLE
6"
2" exh pipe
2" exh pipe
7" OD
FLOW
MARMON FLANGE
T/C Coupling
P_s coupling
8"
EXIT SECTION
CENTERBODY SECTION
ENTRY SECTION

NOTES

1. MAKE 3 EA CENTERBODIES OF STAINLESS (16 GAGE 316) WITH STEEL END FLANGES, 1/4" THICK, SLIP OVER STAINLESS CYLINDER AND HELIARC. FLANGES TO BE 8 1/2" OD DRILLED THROUGH FOR 8 EA 1/4" BOLTS ON A 7 3/4" BOLT CIRCLE. FLANGES SHOULD BE FACED OFF AFTER WELDING TO MAKE TRUE TO EXHAUST FLANGES ON ENTRY & EXIT SECTIONS. USE 3/32 OR 1/8" THICK GASKET, ASBESTOS
2. MAKE 1 EA ENTRY SECTION FROM MILD STEEL TO TRANSITION FROM EXISTING NOMINAL 2" EXHAUST TO 7" OD CENTERBODY. RIGHT CIRCULAR ENTRY CONE TO BE 6 INCH LONG. OPTION OF WELD TO EXISTING 2 INCH EXHAUST PIPE OR USE MARMON CLAMP AS SIMPLER. CAN REWORK EXHAUST PIPE AT ENTRY TO THIS SECTION AS REQUIRED.
3. MAKE 1 EA EXIT SECTION FROM MILD STEEL TO TRANSITION FROM 7 IN OD CENTERBODY TO 2" OD EXHAUST PIPE. SUGGEST WELD ON EXIT OF 8" PIPE A SUITABLE MARMON FITTING FOR USE WITH EXISTING LAB CVS & DILUTION TUNNEL.
4. NOTE LOCATION OF T/C AND P_s FITTINGS. FITTINGS CAN BE 1/4" PIPE HALF COUPLINGS OF EITHER STAINLESS OR STEEL. DRILL THROUGH (CENTER) FOR 1/4" T/C AND CLEAN (DEBUR) STATIC PRESSURE TAP OPENINGS.

11-H016-002

9/15/75 K. J. Springer

Scale 1" = 1'-0"

REAR MUFFLER - MERCEDES 300 D

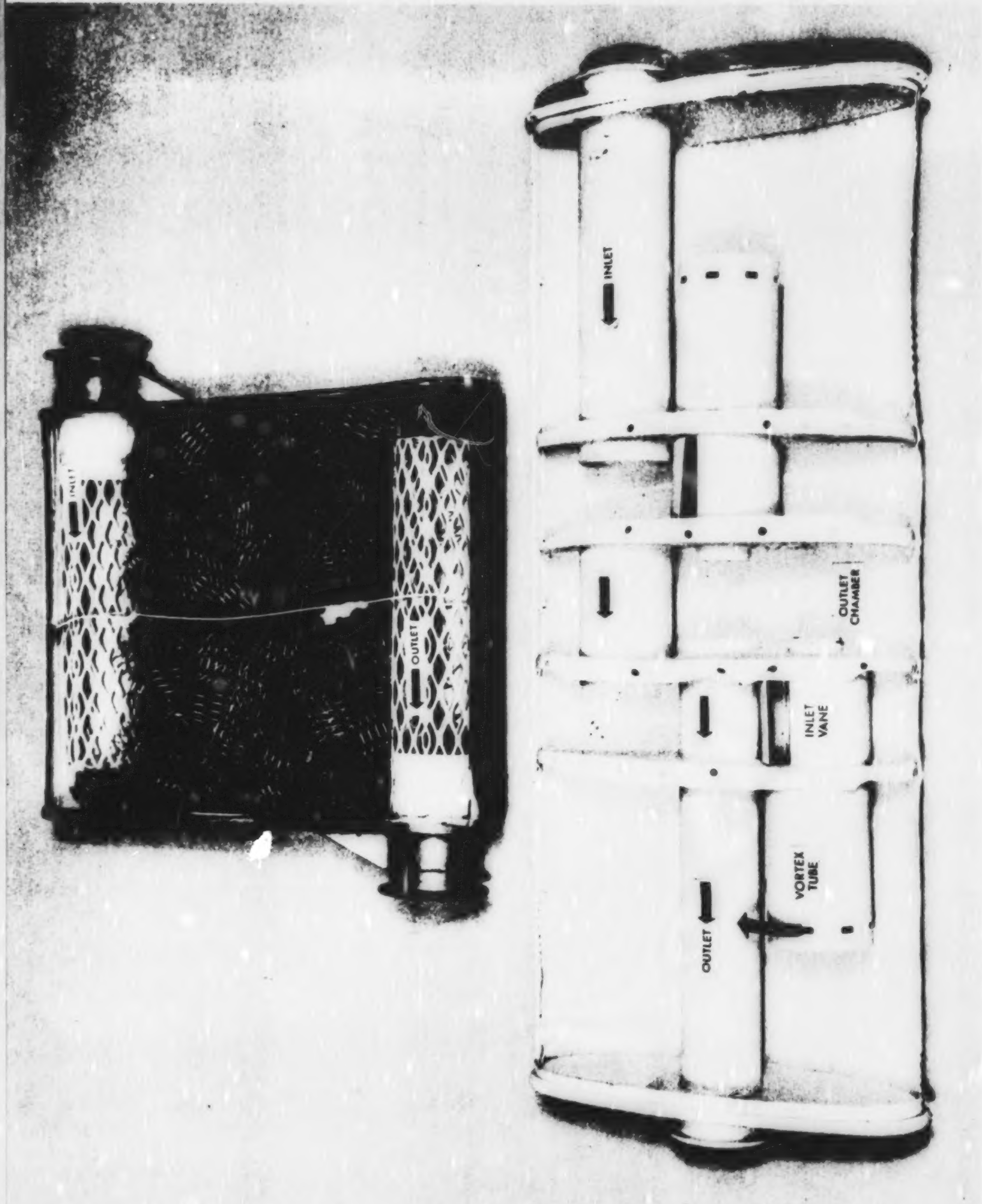

INLET
OUTLET
INLET
OUTLET CHAMBER
INLET VANE
VORTEX TUBE
OUTLET

Figure 2. Agglomerator and Prototype Anchored Vortex Trap(36)

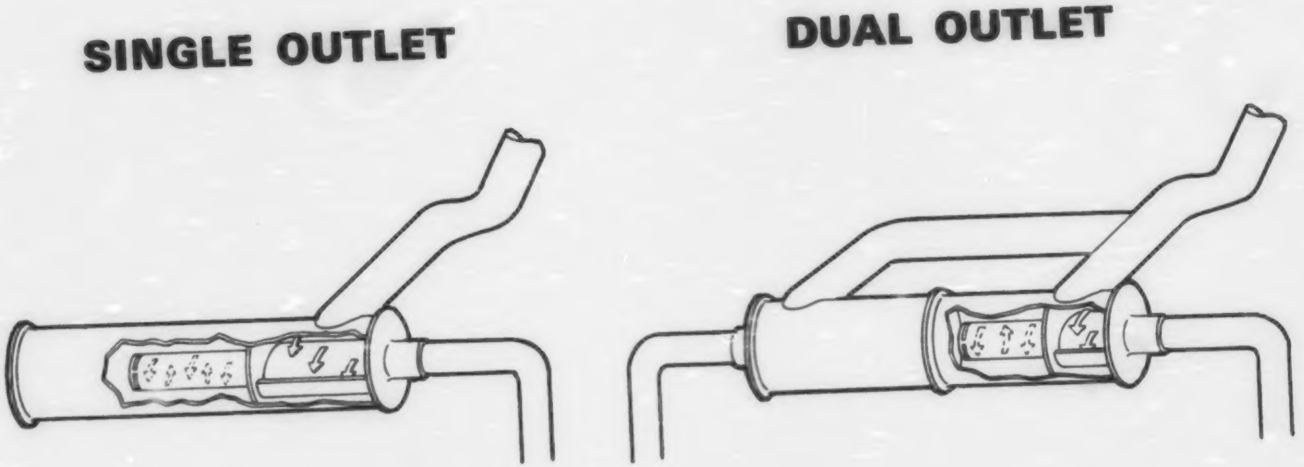

SINGLE OUTLET
DUAL OUTLET

Figure 3. Tangential Anchored Vortex Traps(36, 37)

TEXACO

PETROLEUM PRODUCTS

AUTOMOTIVE ENGINE
DEVELOPMENTS
WILLIAM T. TIERNEY
PROJECT MANAGER

TEXACO INC.
P. O. BOX 509
BEACON, NEW YORK 12508
TEL. (AREA 914) 831-3400

December 2, 1975

Mr. Karl Springer
Southwest Research Institute
8500 Culebra Road
San Antonio, Texas 78284

Dear Karl:

We have forwarded the diesel exhaust smoke filter units to you for your tests on the Mercedes 300D via the United Parcel Service. A copy of the invoice is attached for your reference.

In order to estimate the exhaust back pressure characteristics of the units we conducted flow tests on each of the components. Copies of these test results are attached for your information. You will note that we have tested each unit with both a flat discharge end plate and a conical end plate configuration for each of the two filters. As you can see, the conical discharge results in a reduction in the pressure drop across the unit particularly in the higher gas flow ranges. You may wish to test these filters in both configurations in order to determine the actual effect on car performance and back pressure.

There are other filter configurations that could be used should the conical discharge elements not properly fit the underfloor exhaust system space available. For example, we could pack a subsequent unit with a shorter axial length of material thus providing a plenum which should reduce the back pressure associated with the sharp entry into a flat discharge plate exit pipe. This is a detail, however, that can be looked at in a subsequent situation.

The units that have been forwarded were packed at a density that was our best guess at proper filter efficiency-exhaust back pressure balance. The filter element restriction can be changed, if necessary, by either reducing the axial length of the element or by decreasing the packing density.

This is recycled paper

This too, however, would be the subject of a subsequent test. We are looking forward to receiving information on your initial evaluation so that we may consider the steps desirable for subsequent tests.

If you have any questions on this matter, please do not hesitate to contact me.

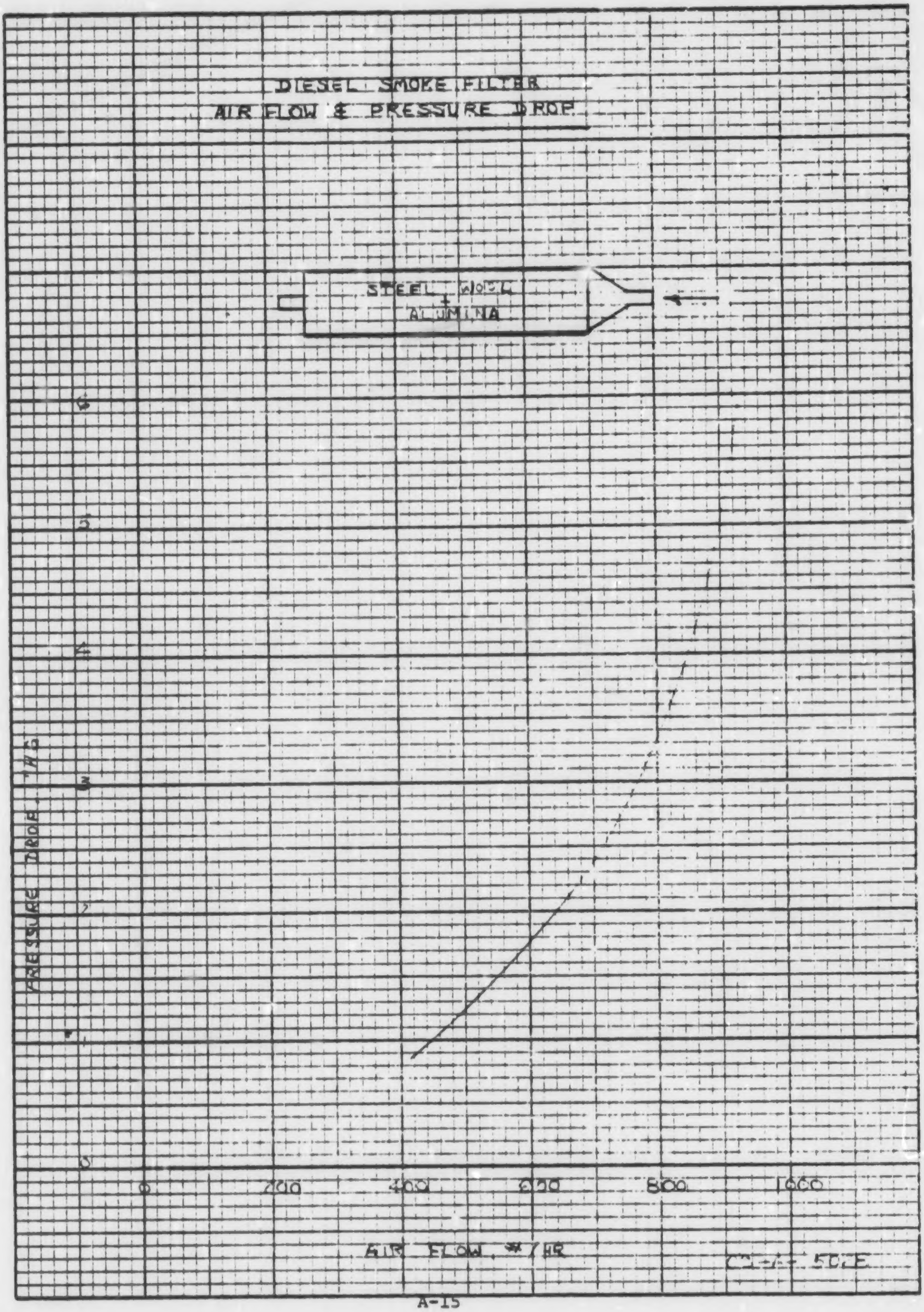
Yours very truly,

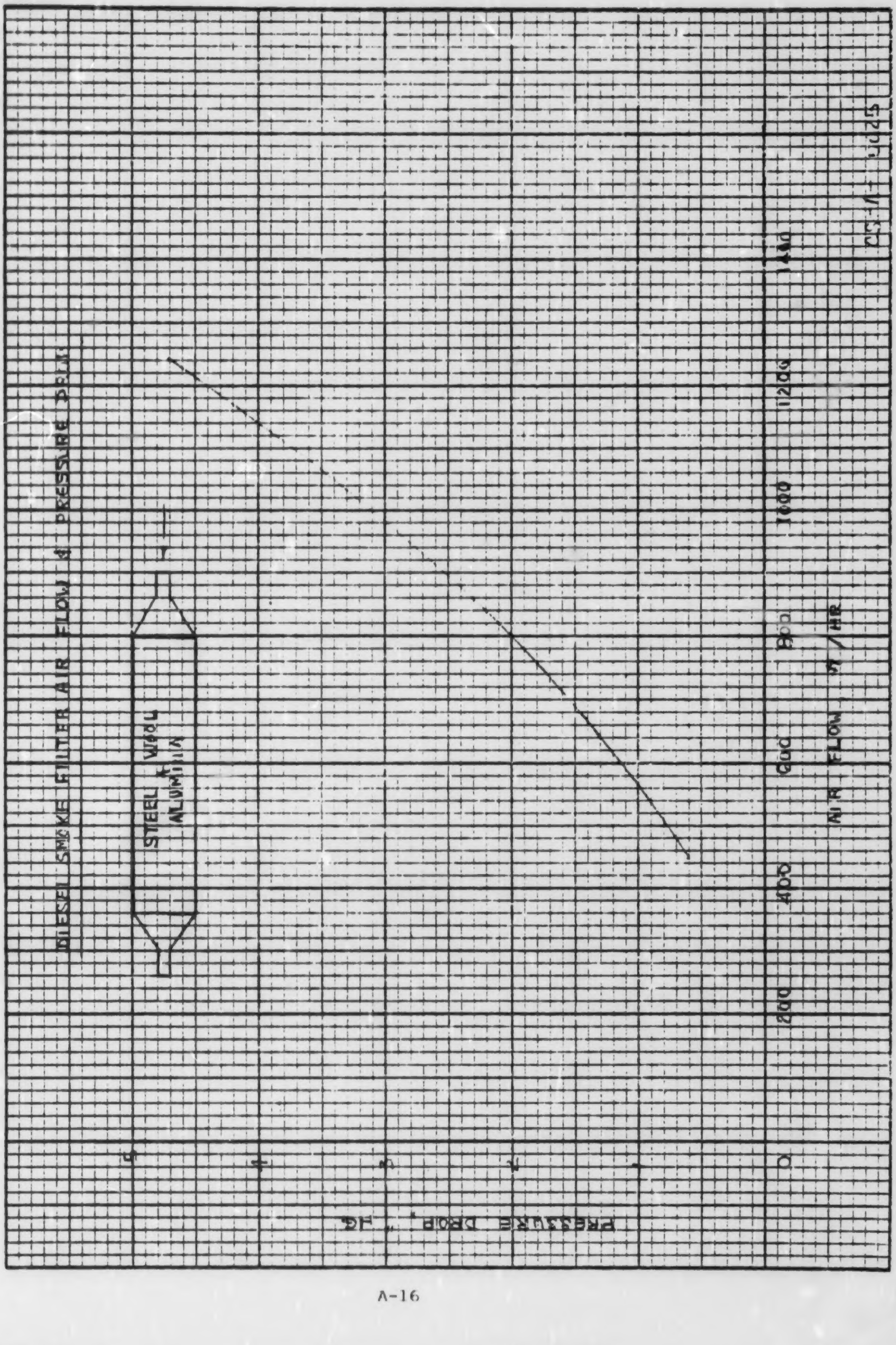
Bill Tierney Jr

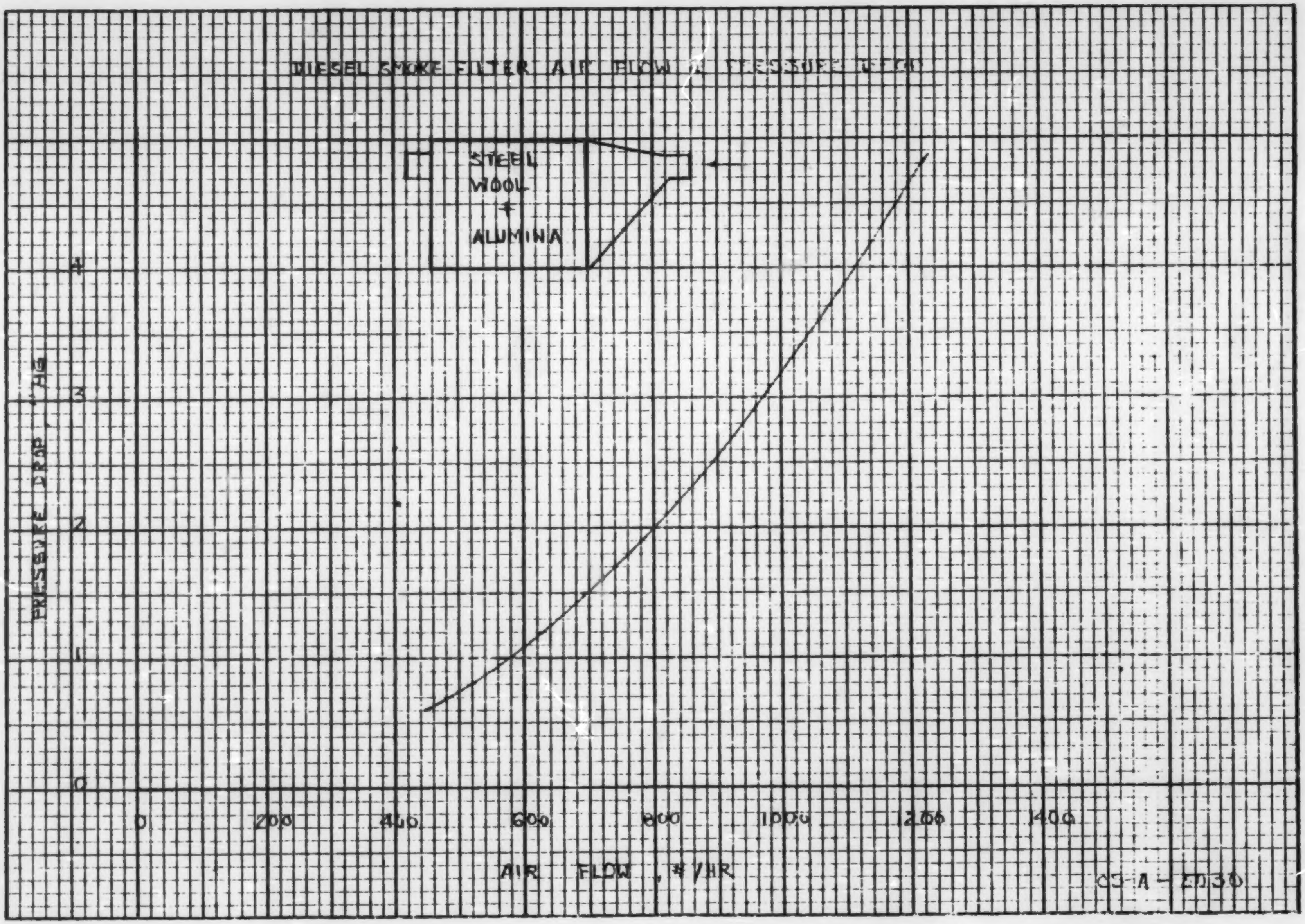
WTT-khc

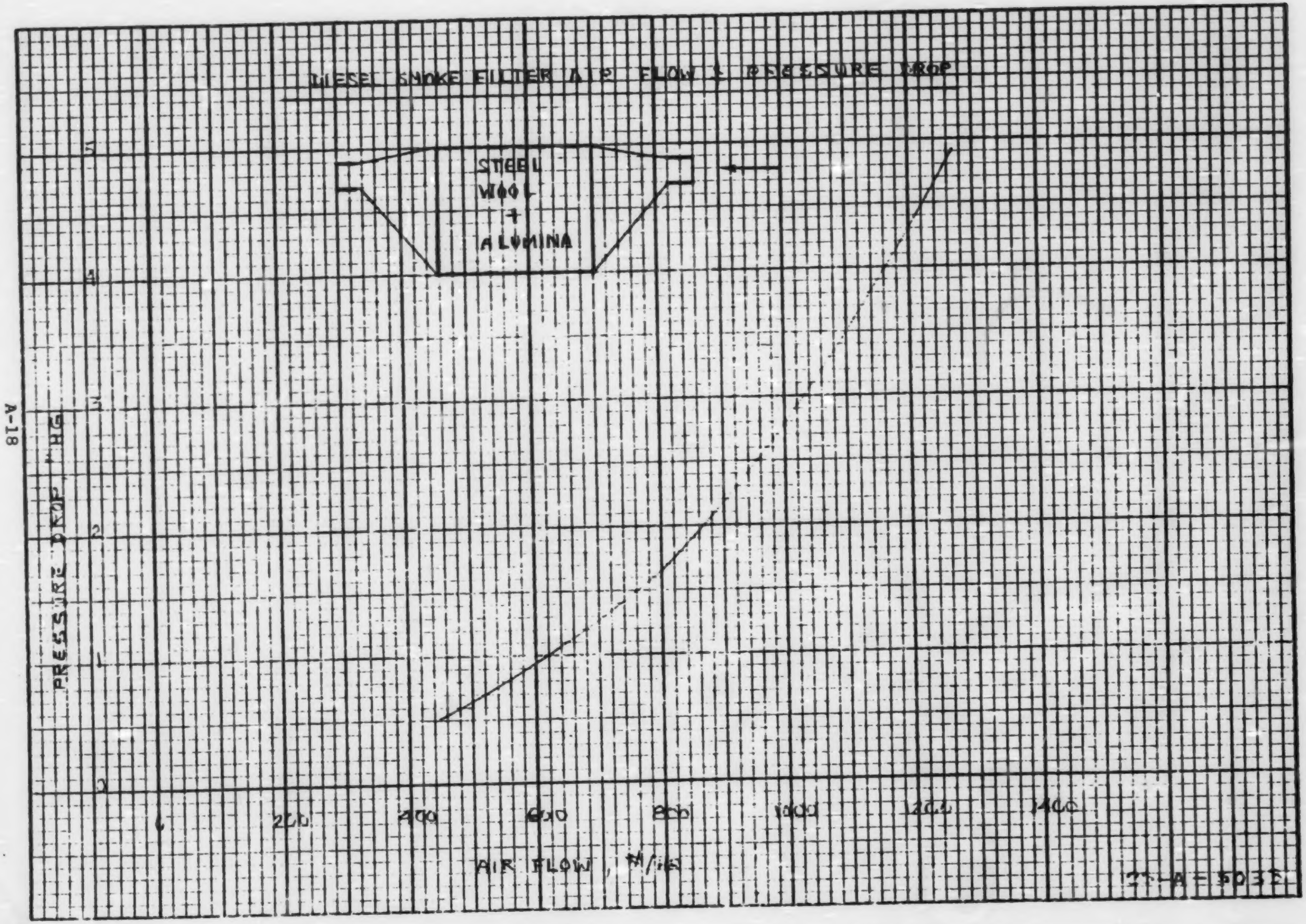
Attachments

NOTE: I am attaching a second copy of this letter for your transmittal to Ralph Stahman should you desire.


DIESEL SMOKE FILTER
AIR FLOW & PRESSURE DROP
STEEL WOOL + ALUMINA
PRESSURE DROP, "HG
0
1
2
3
4
5
6
0
200
400
600
800
1000
AIR FLOW, #/HR


DIESEL SMOKE FILTER AIR FLOW & PRESSURE DROP
STEEL WOOL & ALUMINUM
PRESSURE DROP, " HG
0
1
2
3
4
5
200
400
600
800
1000
1200
1400
AIR FLOW, #/HR
CS-A-4025


DIESEL SMOKE FILTER AIR FLOW & PRESSURE DROP
STEEL
WOOL
+
ALUMINA
PRESSURE DROP, "HG
0
1
2
3
4
0
200
400
600
800
1000
1200
1400
AIR FLOW, #/HR
CJ-A-ED30


DIESEL SMOKE FILTER AIR FLOW & PRESSURE DROP
STEEL
WOOL
+
ALUMINA
PRESSURE DROP " HG
0
1
2
3
4
5
0
200
400
600
800
1000
1200
1400
AIR FLOW, #/HR
27-A-5032

TEXACO

PETROLEUM PRODUCTS

AUTOMOTIVE ENGINE DEVELOPMENTS

WILLIAM T. TIERNEY
PROJECT MANAGER

TEXACO INC.
P. O. BOX 509
BEACON, NEW YORK 12508
TEL. (AREA 914) 831-3400

March 10, 1976

Mr. Karl J. Springer
Southwest Research Institute
8500 Culebra Road
San Antonio, Texas 78284

Dear Karl:

I appreciated receiving the information on the current status of the diesel filter test and would like to have a short note from you containing information on the tests to date. In line with your requests, I discussed the two test units you wish to evaluate in the near future with John Brandenburg. I find that a duplicate of the large unit you have already tested was prepared, however, the alumina material has not been deposited on it. This then is exactly what you want - a filter housing containing just the steel wool. We are forwarding this to you today by United Parcel.

You will note that we have welded two "screens", one on each end of the filter. The steel wool is packed in two ten inch long "biscuits" with approximately three inches of space between the two in the center of the filter. We have flowed this on our air flow calibration rig. The gas flow quantities were higher than the exhaust flow expected from the car and we have noted no tendency for the steel wool biscuit to move in the outer tube. It might be desirable to drill about four holes in the outer case and insert rods into the center of the steel wool biscuit, welding the rods at the outside of the case. This will insure that the upstream biscuit does not move under the impact of exhaust vibrations since the stainless steel wool may lose some of its temper as a result of exhaust temperature. We feel that the dead space between the biscuits is important to the effectiveness of the filter. The unit you have already tested was constructed in the same manner. The unit to be supplied has the same weight of steel wool as the one already in your hands. I note that in my letter to you of December 2 I failed to provide you with the data on the two units you have tested. The following table will confirm the values provided over the telephone yesterday.

(see next page)

	Weight (grams)			
Filter	SS Wool	Case & Supports	Alumina	TOTAL
M1-1	602	3608	1428	5638
M2-1	1199	5831	2752	9782
M2-2	1202	5880	None	7082
M3-1	267*	538	545	1353

*Inconel Mesh

Note: All Weights are taken following drying at 300°F to remove adsorbed water.

The steel wool unit has the same weight of wool as shown for the M-2 unit in the table above.

You indicated that you wish to test a radial flow unit. For this purpose we are supplying an element similar to that previously used as a catalyst support for the work done on the emissions tests on the Army jeep equipped with the TCCS engine. The support for the alumina is a woven inconel mesh. Sample pieces of the uncoated material have been forwarded for your inspection. We do not have a steel wool unit. The detail of the catalytic unit is contained in the attached SAE Paper No. 740563 (see Figures 2 & 7).

The element you will receive has an outer wrap of stainless steel sheet with 1/2" diameter perforations. I feel that the combination of the area reduction imposed by the perforations in both the outer and inner surfaces and the suggested conical outer wrap "muffler" case will provide fairly uniform gas flow through the unit. I am enclosing a copy of Drawing No. CS-D-5104 which suggests a muffler configuration. The initial tests should be made with exhaust flow in the directions shown. You may wish to reverse-flow the unit to see if there is any difference between causing the gas to enter the filter on a large surface or the much reduced surface which would be the case with reverse flow. The detail data on the radial flow element is also shown in the above table as M-3.

You will be interested to know that the potential of the alumina material as a diesel smoke filter has been appreciated by several engine companies, and as a result, we are now considering the supply of additional test units.

During our conversation I mentioned the indication we had that the filter unit appreciably reduces diesel exhaust odor. When you have had an opportunity to consider this matter, I would appreciate hearing from you. You are aware of the fact that the steel wool unit we have sent to you has utilized the last of the large size filter housings and, should we wish to evaluate additional designs, it will be necessary for us to have another unit. Of course, if the test program on the wool unit is short-lived, we could remove the filling and repack. The next unit that would be of interest would be one containing more biscuits with a shorter axial flow path. Since, as you indicated, the current unit has quite low back pressure, I'd suggest the use of higher packing density. A definitive evaluation however would suggest that packing density and the number of biscuits should be considered as separate items for evaluation.

For your convenience, I am attaching an extra copy of this letter which you may wish to give to Jack McFadden for his file. If you have any questions on the foregoing, please do not hesitate to let me know.

Very truly yours,

Bill

W. T. Tierney

WTT-khc

Attachments

cc: Mr. J. J. McFadden
(with copy of drawing)

PETROLEUM PRODUCTS

AUTOMOTIVE ENGINE
DEVELOPMENTS
WILLIAM T. TIERNEY
PROJECT MANAGER

TEXACO INC.
P. O. BOX 509
BEACON, NEW YORK 12508
TEL. (AREA 914) 831-3400

May 10, 1976

Mr. Karl J. Springer
Southwest Research Institute
8500 Culebra Road
San Antonio, Texas 78284

Dear Karl:

Last Friday, May 7, we returned the elbowed sections to you via United Parcel Service. These have been packed for smoke filter service with the alumina support based on stainless steel wool. A sketch of the rod support structure is attached for your information.

As I mentioned to you in the past, other means for assuring good retention of the filter material could be used for a commercial unit, however, the welded rod is a simple way for us to approach this problem. The unit is completely packed without dead space. For your information, the table below lists the weight of the units and the packing in grams as well as the ratio of alumina to steel wool.

	A	B
Case	2570	2572
Steel Wool	236	236
Case + SW + alumina	3189	3275
Alumina (calcined)	383	467
Ratio Al_2O_3	1.62	1.98

Should you wish to weigh the elements to determine how much particulate matter has been retained it should be dried at about 250° to insure that all free water has been removed from the alumina since the above table lists the dry weight.

We will be interested in learning of the results of the tests on these units.

Best regards,

Bill

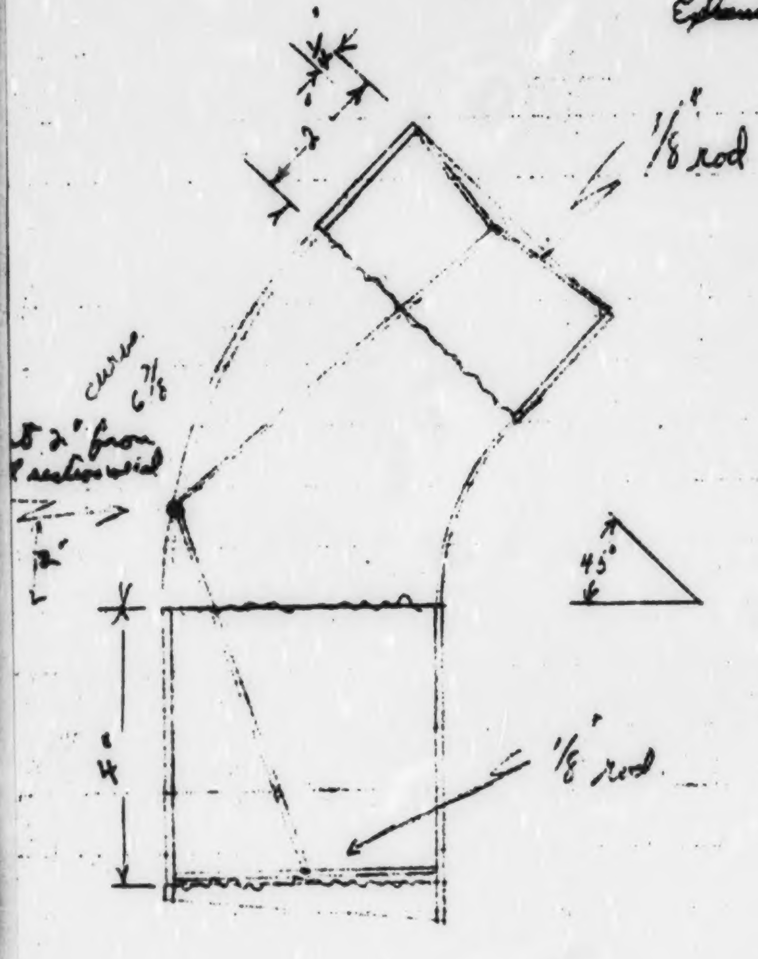
P.S. - For your interna
use, I am attach
3 copies of the
invoice that wil
accompany the
shipment. WTT

WTT-khc
Attachment

This is recycled paper

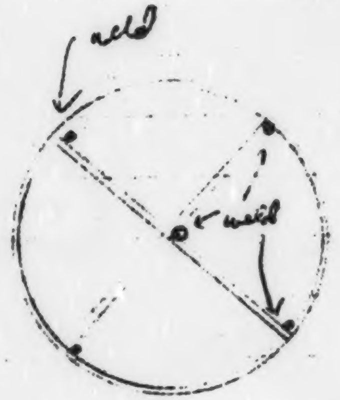
31102-43

Southwest Research Institute
Exhaust gas filter 4/30/76
JMG


1/4"
2"
1/8" rod
curve 6 7/8
t 2" from
section weld
2"
45°
4"
1/8" rod

slight bend in outlet spider (about 1/4")

4" Sch. 10 Stainless Steel (304 pipe, 316-L)
(supplied by SWI)



inlet and outlet spider
outlet to have slight bend

APPENDIX B

MERCEDES 300D ROAD AND CHASSIS DYNAMOMETER TEMPERATURE PROFILES

TABLE B-1. MERCEDES 300D ROAD AND CHASSIS DYNAMOMETER TEMPERATURE PROFILES
1200 sec, 48.3 km/hr LEVEL ROAD CRUISE

	Road			Dyno		
Reading	Run 1	Run 2	Avg.			Avg.
Exhaust Manifold, °C(1)	190	170	180	184	176	180
	(280-136)	(248-136)		(186-182)	(180-172)	
Integrator, °C	---	---			160	160
Pipe Flange, °C(1)	170	150	160		165	
	(220-130)	(193-130)		---	(170-160)	
Muffler 1 Inlet, °C(1)	160	140	150	160	155	158
	(178-125)	(160-123)		(162-159)	(157-152)	
Integrator, °C	148	129	139	148	134	141
Muffler 1 Outlet, °C(1)	150	130	140	150	136	143
	(165-124)	(138-120)		(151-149)	(140-132)	
Integrator, °C	142	123	133	141	150	146
Muffler 2 Inlet, °C(1)	145	125	135	147	135	141
	(160-119)	(135-118)		(148-145)	(140-132)	
Muffler 2 Outlet, °C(2)	143	124	134	137	132	135
	(165-129)	(130-114)		(138-136)	(138-91)	
Bumper Ambient, °C(3)	32	28	30	23	27	25
	(32-31)	(29-25)		(23-23)	(27-27)	
Water Out, °C(3)	57	51	54	44	53	49
	(64-55)	(56-49)		(45-42)	(53-52)	
Engine Air In, °C(3)	39	32	36	29	37	33
	(40-38)	(33-30)		(30-29)	(46-35)	
Oil Sump, °C(3)	92	89	91	89	93	91
	(95-91)	(91-84)		(92-85)	(94-89)	
Exhaust Man, mm Hg(1)				14	15	15
				(15-13)	(15-15)	
Gage, mm Hg(2)				14	12	13
				(15-13)	(13-10)	
Pipe Flange, mm Hg(2)				14	14	14
				(15-13)	(15-13)	
Muffler 1 Inlet, mm Hg(2)				12	11	12
				(12-11)	(11-11)	
Muffler 2 Inlet, mm Hg(2)				7	7	7
				(8-7)	(8-7)	

(maximum-minimum)
(1) visual estimates of continuous trace
(2) readings taken every minute
(3) readings taken every two minutes
(4) fan located 2.87 m from bumper
(5) fan located 4.39 m from bumper

TABLE B-2. MERCEDES 300D ROAD AND CHASSIS DYNAMOMETER TEMPERATURE PROFILES
600 sec, 96.5 km/hr LEVEL ROAD CRUISE

Reading	Road			Dyno		
	Run 1)	Run 2	Avg.			Avg.
Exhaust Manifold, °C(1)	300 (412-260)	310 (464-288)	305	320 (322-312)	332 (336-312)	326
Integrator, °C	---	---		312	---	312
Pipe Flange, °C(1)	270 (358-252)	295 (420-270)	283	---	315 (321-305)	315
Muffler 1 Inlet, °C(1)	255 (295-228)	285 (343-245)	270	306 (308-305)	300 (303-288)	303
Integrator, °C	248	294	271	297	286	292
Muffler 1 Outlet, °C(1)	245 (275-225)	280 (320-245)	263	288 (288-285)	275 (278-258)	282
Integrator, °C	235	277	256	276	262	269
Muffler 2 Inlet, °C(1)	235 (270-220)	265 (308-233)	250	285 (289-280)	270 (276-260)	278
Muffler 2 Outlet, °C(2)	234 (247-223)	260 (278-237)	247	273 (274-267)	248 (274-81)	261
Bumper Ambient, °C(3)	31 (32-31)	28 (29-25)	30	23 (23-23)	27 (27-27)	25
Water Out, °C(3)	79 (79-78)	78 (79-77)	78	81 (82-81)	75 (83-38)	78
Engine Air In, °C(3)	39 (40-38)	34 (36-29)	37	42 (43-40)	42 (45-34)	42
Oil Sump, °C(3)	101 (102-100)	101 (102-98)	101	102 (103-102)	101 (106-89)	101
Exhaust Man, mm Hg(1)				54 (57-52)	63 (64-62)	59
Gage, mm Hg(2)				57 (58-56)	52 (53-51)	55
Pipe Flange, mm Mg(2)				77 (70-76)	67 (69-66)	72
Muffler 1 Inlet, mm Hg(2)				51 (51-51)	49 (49-49)	50
Muffler 2 Inlet, mm Hg(2)				33 (33-32)	31 (31-30)	32

(maximum-minimum)
(1) visual estimates of continuous trace
(2) readings taken every minute
(3) readings taken every two minutes
(4) fan located 2.87 m from bumper
(5) fan located 4.39 m from bumper

TABLE B-3. MERCEDES 300D ROAD AND CHASSIS DYNAMOMETER TEMPERATURE PROFILES
1398 sec., 21.74 km, SULFATE (SET) S-7 CYCLE

	Road			Dyno	
Reading	Run 1	Run 2	Avg	Run 1(4)	Run 2(5)
Exhaust Manifold, °C(1)	260 (544-132)	250 (512-140)	255	225 (384-156)	220 (384-144)
Integrator, °C	---	---	---	223	223
Pipe Flange, °C(1)	210 (425-145)	200 (405-150)	205	205 (375-123)	200 (378-114)
Muffler 1 Inlet, °C(1)	205 (335-138)	200 (325-138)	203	200 (338-130)	200 (330-110)
Integrator, °C	196	204	200	199	202
Muffler 1 Outlet, °C(1)	195 (303-137)	190 (298-138)	193	190 (283-118)	190 (273-105)
Integrator, °C	189	196	193	188	190
Muffler 2 Inlet, °C(1)	187 (293-135)	196 (288-134)	192	190 (283-111)	190 (275-103)
Muffler 2 Outlet, °C(2)	184 (226-127)	195 (258-131)	190	188 (253-114)	187 (251-92)
Bumper Ambient, °C(3)	32 (37-29)	32 (33-31)	32	26 (27-25)	26 (27-26)
Water Out, °C(3)	76 (86-66)	72 (77-64)	74	66 (79-46)	68 (81-53)
Engine Air In, °C(3)	46 (71-38)	40 (51-36)	43	37 (41-34)	40 (48-37)
Oil Sump, °C(3)	97 (101-93)	97 (101-93)	97	98 (103-91)	98 (104-90)
Exhaust Man, mm Hg(1)				31 (57.0-5.2)	31 (59.6-5.2)

(Max-Min)
(1) Visual Estimates of Continuous Trace
(2) Readings Taken Every Minute
(3) Readings Taken Every Two Minutes
(4) Fan located 2.87 m from Bumper
(5) Fan located 4.39 m from Bumper

TABLE B-4. MERCEDES 300D ROAD AND CHASSIS DYNAMOMETER TEMPERATURE PROFILES
765 sec., 16.48 km, FUEL ECONOMY TEST (FET) CYCLE

Reading	Road			Dyno	
	Run 1	Run 2	Avg	Run 1(4)	Run 2(5)
Exhaust Manifold, °C	260 (464-128)	290 (516-132)	275	255 (344-160)	260 (348-160)
Integrator, °C	---	---	---	254	259
Pipe Flange, °C(1)	240 (368-150)	270 (423-155)	265	240 (335-150)	245 (345-150)
Muffler 1 Inlet, °C(1)	215 (293-145)	240 (345-148)	228	230 (300-150)	235 (315-153)
Integrator, °C	213	238	226	232	236
Muffler 1 Outlet, °C(1)	205 (270-155)	230 (313-158)	218	215 (268-140)	220 (265-158)
Integrator, °C	204	226	215	214	219
Muffler 2 Inlet, °C(1)	200 (265-150)	220 (303-155)	210	200 (273-138)	210 (285-155)
Muffler 2 Outlet, °C(2)	201 (230-171)	222 (262-188)	212	202 (254-85)	209 (254-114)
Bumper Ambient, °C(3)	32 (37-31)	32 (32-32)	32	27 (27-26)	27 (28-26)
Water Out, °C(3)	76 (81-71)	75 (79-72)	75	71 (81-50)	74 (82-63)
Engine Air In, °C(3)	41 (48-38)	39 (44-37)	40	41 (46-37)	42 (51-39)
Oil Sump, °C(3)	98 (101-97)	98 (102-96)	98	99 (104-89)	101 (105-92)
Exhaust Man, mm Hg(1)				41 (55.7-10.4)	40 (66.0-9.1)

(Max-Min)
(1) Visual Estimates of Continuous Trace
(2) Readings Taken Every Minute
(3) Readings Taken Every Two Minutes
(4) Fan located 2.87 m from Bumper
(5) Fan located 4.39 m from Bumper

APPENDIX C

PARTICULATE TRAP EVALUATION DATA
SINGLE COMPONENTS AND COMBINATIONS

TABLE C-1. PARTICULATE TRAP EVALUATION DATA

Date: 1-23-76
Description of Item: Factory Mufflers - Stock System Initial Baseline

			Average temperatures, °C		
Run No.	Type Test	Particulate g/km	Exh. Manifold	Muffler No. 1 Inlet	Muffler No. 1 Outlet
1	Cold	0.256	192	173	138
2	Hot	0.280	211	187	168
3	Hot	0.263	210	185	165
4	Hot	0.259	210	181	169
5	Hot	0.268	204	184	164
6	Hot	0.265	204	182	163
7	Hot	0.279	204	180	165
8	Hot	0.282	199	174	158
9	Hot	0.262	199	175	160
10	Hot	0.269	198	174	159
Avg.	Hot	0.270	204	180	161

At 80.5 km/hr during test the following pressures were noted:

P_1 - 28.89 mm Hg
ΔP - 15.88 mm Hg
P_2 - 14.01 mm Hg

No steady state temperatures or pressures taken after these runs

TABLE C-2. PARTICULATE TRAP EVALUATION DATA

Date: 1-27-76
Description of item: HCC Small Swirl Separator

Run No.	Type Test	Particulate g/km	Average Temperature °C Exhaust Manifold	Trap Inlet	Trap Outlet
1	Cold	0.250	194	176	163
2	Hot	0.238	196	174	164
3	Hot	0.258	198	178	167
4	Hot	0.251	198	179	168
5	Hot	0.281	197	178	167
Avg.	Hot	0.257	197	177	166

Steady State Pressures and Temperatures

	Vehicle Speed, km/hr 0	16.1	32.2	48.3	64.4	80.4	96.5
				Temperatures, °C(1)			
Ambient Air	26	26	26	25	26	25	26
Intake Air	46	55	49	43	44	48	54
Engine Water	68	72	64	59	66	79	85
Engine Oil	93	91	92	93	95	99	105
Exhaust Man.	157	154	162	180	212	256	312
Before Trap	135	131	145	161	195	238	300
After Trap	114	125	138	149	182	224	282
				Pressures, mm Hg			
Before Trap	0.9	4.6	6.5	8.4	15.9	25.8	38.3
ΔP	1.9	4.6	5.6	6.5	12.1	17.7	26.2
After Trap	Neg	Neg	0.7	1.1	3.7	7.5	11.6

(1) After 5 minute, 80.4 km/hr warm up

TABLE C-3. PARTICULATE TRAP EVALUATION DATA

Date: 1-28-76
Description of item: HCC Small Cyclone Separator

			Average Temperatures, °C		
Run. No.	Type Test	Particulate g/km	Exhaust Manifold	Trap Inlet	Trap Outlet
1	Cold	0.242	206	186	156
2	Hot	0.213	201	178	151
3	Hot	0.203	204	180	151
Avg.	Hot	0.208	202	179	151

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
				Temperatures, °C(1)			
Ambient Air	28	34	29	28	27	27	28
Intake Air	84	60	53	48	47	50	58
Engine Water	78	77	71	66	70	80	86
Engine Oil	96	95	95	95	96	100	107
Exhaust Man.	168	160	168	188	226	284	360
Before Trap	125	130	148	168	206	262	332
After Trap	112	110	122	140	170	215	278
				Pressures, mm Hg			
Before Trap	7.6	35.6	55.9	66.0	121.9	198.0	274.3
ΔP	7.6	33.0	50.8	58.4	109.2	170.2	236.2
After Trap	Neg	3.7	6.5	8.4	15.9	27.1	38.3

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(1) After 5 minute, 80.4 km/hr warm up.

TABLE C-4. PARTICULATE TRAP EVALUATION DATA

Date: 1-28-76
Description of item: HCC Large Cyclone Separator

Run No.	Type Test	Particulate g/km	Average Temperatures, °C Exhaust Manifold	Trap Inlet	Trap Outlet
1	Hot	0.209	191	172	136
2	Hot	0.232	201	176	137
3	Hot	0.227	209	172	134
Avg.		0.223	200	173	136

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C$^{(1)}$							
Ambient Air	26	28	25	26	26	26	27
Intake Air	50	60	59	49	47	49	55
Engine Water	78	80	75	65	68	74	83
Engine Oil	97	95	95	94	94	97	103
Exhaust Man.	164	160	168	184	220	256	336
Before Trap	131	132	148	165	200	250	322
After Trap	112	108	118	131	158	200	260
Pressures, mm Hg							
Before Trap	2.5	15.2	20.3	25.4	55.9	78.7	114.3
ΔP	2.5	10.1	15.2	20.3	40.6	58.4	83.8
After Trap	0	4.7	5.5	5.5	14.1	21.1	31.1

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(1) After 5 minute, 80.4 km/hr warm up.

TABLE C-5. PARTICULATE TRAP EVALUATION DATA

Date: 1/29 and 1/30/76
Description of Item: Texaco A-IR, Alumina Coated Steel Wool Agglomerator

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Trap Inlet	Trap Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Hot	0.100	195	155	141	-
2	Hot	0.078	199	155	144	38.3
3	Hot	0.089	203	163	156	38.3
4	Hot	0.090	206	163	157	38.3
5	Cold	0.097	196	160	148	39.6
6	Hot	0.086	203	161	156	41.6
7	Hot	0.092	201	162	157	40.5
8	Hot	0.097	203	160	158	40.2
Avg.	Hot	0.090	201	160	152	39.5

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	26	26	26	25	26	26	26
Intake Air	50	54	46	42	45	49	55
Engine Water	70	66	56	56	62	75	84
Engine Oil	99	96	94	93	94	98	104
Exhaust Manifold	176	162	162	180	214	258	318
Before Trap	145	131	132	144	182	222	276
After Trap	180	167	140	136	153	186	240
Pressures, mm Hg							
Before Trap	3.2	12.1	17.0	20.7	31.6	47.3	67.6
ΔP	4.7	12.1	15.9	17.2	28.2	43.3	61.8
After Trap	Neg	0	2.8	3.9	4.7	5.0	8.0

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-6. PARTICULATE TRAP EVALUATION DATA

Date: 1/30 and 2/2/76
Description of Item: HCC-137 Packed Bed Agglomerator, Nominal
(8 mm) 1/4 inch diameter alumina spheres

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Trap Inlet	Trap Outlet	at 80.4 km/hr after run
1	Hot	0.203	198	163	144	20.2
2	Hot	0.223	203	166	150	20.9
3	Hot	0.231	205	166	149	20.7
4	Hot	0.224	205	166	149	20.8
5	Cold	0.248	203	164	139	21.5
6	Hot	0.222	203	163	148	21.5
7	Hot	0.216	202	163	147	20.9
8	Hot	0.243	205	165	150	20.9
Avg.	Hot	0.223	203	165	148	20.8

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	23	24	23	24	24
Intake Air	53	59	50	43	44	47	56
Engine Water	72	70	60	57	60	69	84
Engine Oil	101	98	97	96	94	98	105
Exhaust Manifold	186	166	166	182	210	258	320
Before Trap	145	-	137	149	184	231	291
After Trap	162	162	120	141	162	199	252
Pressures, mm Hg							
Before Trap	0.9	5.8	9.2	9.7	18.5	27.8	40.7
ΔP	2.2	5.2	7.6	8.0	14.0	20.9	30.8
After Trap	Neg	0	0.9	1.3	3.4	6.2	9.5

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-7. PARTICULATE TRAP EVALUATION DATA

Date: 2/2 and 2/3/76
Description of Item: Ethyl Corp. Agglomerator packed with Chopped Lath

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Avg. Temperatures, °C Trap Inlet	Avg. Temperatures, °C Trap Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Hot	0.270	196	164	149	6.4
2	Hot	0.247	201	162	148	6.4
3	Hot	0.245	202	166	155	6.4
4	Hot	0.253	204	166	154	6.8
5	Cold	0.301	191	161	145	6.4
6	Hot	0.259	201	165	154	6.4
7	Hot	0.270	203	169	158	6.4
8	Hot	0.267	204	162	149	6.4
Avg.	Hot	0.259	202	165	152	6.4

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	26	25	25	25	26	26	26
Intake Air	59	60	54	47	46	49	54
Engine Water	73	70	63	62	64	73	82
Engine Oil	100	98	97	96	96	98	103
Exhaust Manifold	182	165	169	186	214	258	318
Before Trap	158	136	139	150	186	230	290
After Trap	168	142	137	142	172	212	269
Pressures, mm Hg							
Before Trap	0.2	2.8	4.3	5.0	9.5	15.1	23.4
ΔP	0.9	2.2	2.8	3.2	4.7	6.9	10.3
After Trap	Neg	0.9	1.3	1.5	4.3	8.0	12.9

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[1] After 5 minute, 80.4 km/hr warmup

TABLE C-8. PARTICULATE TRAP EVALUATION DATA

Date: 2/3 and 2/4/76
Description of Item: Ethyl "TAV" Separator, single

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Trap Inlet	Trap Outlet	at 80.4 km/hr after run
1	Hot	0.205	206	166	149	74.9
2	Hot	0.201	208	172	158	75.7
3	Hot	0.209	213	174	159	74.9
4	Cold	0.235	204	165	148	74.9
5	Hot	0.207	206	164	148	74.9
6	Hot	0.208	208	164	150	74.9
7	Hot	0.200	210	162	147	74.9
8	Hot	0.200	210	164	148	74.5
Avg.	Hot	0.204	209	166	151	75.0

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	27	24	24	25	23	24	24
Intake Air	54	60	48	44	45	48	56
Engine Water	73	68	59	57	63	75	84
Engine Oil	99	96	94	93	95	99	104
Exhaust Manifold	184	164	168	184	220	268	336
Before Trap	128	130	140	155	190	238	305
After Trap	125	122	131	142	175	218	282
Pressures, mm Hg							
Before Trap	4.7	15.9	26.3	27.1	49.5	83.1	127.9
ΔP	3.9	12.9	20.2	23.3	45.4	75.6	113.0
After Trap	0	1.9	4.7	4.7	4.5	8.2	13.3

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-9. PARTICULATE TRAP EVALUATION DATA

Date: 2/5/76
Description of Item: Texaco A-IR with exit cavity and center bed temperature

Run No.	Type Test	Particulate g/km	Average Temperature, °C Exhaust Manifold	Trap Inlet	Trap Center	Trap Outlet	System ΔP, mm at 80.4 km/h after run
1	Cold	0.176	-	160	159	157	42.0
2	Hot	0.129	-	161	158	150	42.0
3	Hot	0.126	-	167	157	149	42.0
4	Hot	0.146	-	163	154	143	42.0
5	Hot	0.134	-	170	159	153	42.0
6	Hot	0.121	-	166	156	148	45.8
7	Hot	0.128	-	171	161	153	45.8
8	Hot	0.128	-	171	161	153	45.8
Avg.	Hot	0.130	-(1)	167	158	150	43.6

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(2)							
Ambient Air	25	25	26	26	27	27	26
Intake Air	50	57	49	44	44	47	52
Engine Water	69	72	60	57	58	72	80
Engine Oil	97	96	93	93	93	96	102
Before Trap	150	135	133	150	180	220	283
Trap Center	170	140	140	150	180	220	283
After Trap	175	160	148	145	158	190	243
Pressures, mm Hg							
Before Trap	4.7	14.6	17.7	19.1	33.7	49.5	70.0
ΔP	5.8	14.0	16.6	17.7	30.3	45.8	65.8
After Trap	Neg.	0	0	0.9	2.8	3.9	6.5

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(1) Exhaust manifold temperature not recorded during these runs
(2) After 5 minute, 80.4 km/hr warmup

TABLE C-10. PARTICULATE TRAP EVALUATION DATA

Date: 2/6/76
Description of Item: Bus Catalytic Muffler, Empty

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Trap Inlet	Trap Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Hot	0.255	189	156	119	0.9
2	Hot	0.248	195	160	128	0.9
3	Hot	0.248	195	163	129	0.9
4	Hot	0.250	195	160	128	0.9
Avg.	Hot	0.250	194	160	126	0.9

Steady State Temperatures and Pressures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	23	23	24	24	24	25
Intake Air	59	64	56	53	48	48	53
Engine Water	82	79	64	64	66	72	81
Engine Oil	100	98	97	96	96	99	103
Exhaust Manifold	163	166	167	174	213	255	312
Before Trap	140	136	142	151	184	228	285
After Trap	138	129	126	130	148	179	224
Pressures, mm Hg							
Before Trap	Neg.	0.6	1.1	1.5	3.2	3.4	5.1
ΔP	0.9	1.3	0.9	0.9	0.7	0.5	0.5
After Trap	Neg.	Neg.	0.5	0.7	2.9	3.2	5.1

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-11. PARTICULATE TRAP EVALUATION DATA

Date: 2/6 and 2/9/76
Description of Item: Bus Catalytic Muffler with 60 lbs Alumina spheres
8mm (1/4 inch) nominal size

			Avg. Temperatures, °C			System ΔP, mm Hg at 80.4 km/hr
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Trap Inlet	Trap Outlet	after run
1	Hot	0.305	191	160	120	0.9
2	Hot	0.284	193	162	128	0.9
3	Hot	0.258	198	168	140	0.9
4	Hot	0.232	195	162	133	0.9
5	Cold	0.246	191	162	87	0.9
6	Hot	0.208	196	163	123	0.9
7	Hot	0.234	197	165	130	0.9
8	Hot	0.241	193	162	90	0.9
Avg.	Hot	0.252	194	163	123	0.9

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	24	24	25	24
Intake Air	59	58	43	42	46	53	60
Engine Water	73	63	53	54	66	79	85
Engine Oil	95	93	93	93	94	100	107
Exhaust Manifold	160	152	160	180	212	260	320
Before Trap	150	132	140	155	191	232	292
After Trap	121	122	125	130	142	156	175
Pressures, mm Hg							
Before Trap	0	0.3	1.5	1.7	3.1	5.6	9.2
ΔP	0.6	1.5	0.9	0.9	1.3	0.9	0.9
After Trap	Neg	Neg	0.4	0.7	2.8	5.6	8.4

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-12. PARTICULATE TRAP EVALUATION DATA

Date: 2/10 and 2/11/76

Description of Combination: Texaco A-IR Agglomerator with exit cavity and Ethyl TAV single separator

Run No.	Type Test	Particulate g/km	Average Temperatures, °C				System ΔP, mm Hg at 80.4 km/hr after run
			Exhaust Manifold	A-IR Inlet	Between Units	Ethyl Outlet	
1	Hot	0.117	198	165	152	143	152.4
2	Hot	0.117	200	162	151	141	147.3
3	Hot	0.107	197	162	151	141	147.3
4	Hot	0.112	198	164	149	139	147.3
5	Cold	0.168	201	167	144	135	149.9
6	Hot	0.136	199	166	153	143	149.9
7	Hot	0.138	198	162	146	136	147.3
8	Hot	0.137	200	163	146	138	149.9
Avg.	Hot	0.123	198	163	150	140	148.8

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
	Temperatures, °C(1)						
Ambient Air	24	24	24	24	24	24	24
Intake Air	32	32	32	32	34	38	42
Engine Water	54	44	43	46	53	72	82
Engine Oil	89	89	86	86	90	96	103
Exhaust Man.	144	128	142	164	210	264	332
Before Comb.	105	102	118	138	179	232	295
After Comb.	152	131	118	118	140	180	235
	Pressures, mm Hg						
Before Comb.	12.7	40.6	53.3	58.4	101.6	162.6	228.6
ΔP	12.7	40.6	53.3	58.4	101.6	157.5	221.0
After Comb.	0	0	0	0	1.5	3.5	6.2
Before A-IR	7.6	38.1	53.3	58.4	104.1	160.0	236.2
ΔP	2.5	12.7	17.9	20.3	35.6	50.8	71.1
After A-IR	4.7	23.4	31.7	37.4	65.4	104.6	160.6
Before TAV_s	7.6	27.9	38.1	43.2	76.2	121.9	175.3
ΔP	7.6	27.9	38.1	40.6	73.7	116.8	167.6
After TAV_s	0	0	0	0.2	1.9	4.2	6.7

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(1) After 5 minute, 80.4 km/hr warmup.

TABLE C-13. PARTICULATE TRAP EVALUATION DATA

Date: 2/12/76

Description of Combination: Texaco A-IR Agglomerator with exit cavity and HCC small swirl separator

Run No.	Type Test	Particulate g/km	Average Temperatures, °C				System ΔP mm Hg at 80.4 km/hr after run
			Exhaust Manifold	A-IR Inlet	Between Units	Cyclone Outlet	
1	Cold	0.238	196	164	143	137	58.4
2	Hot	0.176	195	158	149	143	58.4
3	Hot	0.178	194	161	145	139	55.9
4	Hot	0.170	197	168	157	152	58.4
5	Hot	0.188	197	168	159	154	61.0
6	Hot	0.164	195	161	150	144	55.9
7	Hot	0.183	190	160	146	141	58.4
8	Hot	0.174	193	161	146	140	55.9
Avg.	Hot	0.176	194	162	150	144	57.7

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	24	24	24	24
Intake Air	41	40	39	39	40	42	45
Engine Water	55	55	51	54	58	70	80
Engine Oil	94	94	94	93	94	97	101
Exhaust Man.	116	126	148	168	204	261	316
Before Comb.	85	106	130	146	183	238	295
After Comb.	108	102	108	122	148	210	252
Pressures, mm Hg							
Before Comb.	5.1	20.3	25.4	30.5	50.8	76.2	111.8
ΔP	7.6	20.3	25.4	30.5	50.8	73.7	106.7
After Comb.	Neg.	0	0.4	0.4	0.4	5.0	8.2
Before A-IR	5.1	15.2	25.4	30.5	53.3	81.3	114.3
ΔP	2.5	12.7	22.9	25.4	45.7	66.0	86.4
After A-IR	0	2.0	4.1	5.0	11.0	18.7	29.9

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-14. PARTICULATE TRAP EVALUATION DATA

Date: 2/13/76

Description of Combination: Texaco A-IR Agglomerator with exit cavity and HCC large cyclone separator

Run No.	Type Test	Particulate g/km	Average Temperatures, °C				System ΔP, mm Hg at 80.4 km/hr after run
			Exhaust Manifold	A-IR Inlet	Between Units	Cyclone Outlet	
1	Cold	0.198	202	169	148	127	114.3
2	Hot	0.175	201	171	164	144	114.3
3	Hot	0.166	201	165	154	134	114.3
Avg.	Hot	0.170	201	168	159	139	114.3

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C$^{(1)}$							
Ambient Air	27	27	27	27	27	27	28
Intake Air	33	37	36	37	40	46	50
Engine Water	46	47	47	50	64	79	85
Engine Oil	87	88	88	90	95	101	107
Exhaust Man.	140	132	144	164	206	272	336
Before Comb.	100	102	120	140	182	239	302
After Comb.	125	108	102	106	130	180	222
Pressures, mm Hg							
Before Comb.	5.1	30.5	45.7	48.3	88.9	137.2	195.6
ΔP	7.6	27.9	38.1	43.2	78.7	119.4	172.7
After Comb.	Neg	1.1	4.7	5.2	11.8	20.0	29.9
Before A-IR	5.1	30.5	43.2	48.3	86.4	137.2	198.1
ΔP	5.1	12.7	22.9	25.4	43.2	66.0	86.4
After A-IR	0	14.0	21.3	24.3	46.7	72.8	108.3
Before Cyclone	5.1	12.7	22.8	25.4	48.3	78.7	111.8
ΔP	2.5	10.2	17.8	20.3	35.6	58.4	83.8
After Cyclone	0	2.2	4.9	5.2	11.3	18.7	28.0

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-15. PARTICULATE TRAP EVALUATION DATA

Date: 2/16/76
Description of Combination: HCC-317, packed bed agglomerator and Ethyl TAV single separator

			Average Temperatures, °C				
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Before HCC-137	Between Units	After TAV_s	System ΔP, mmHg at 80.4 km/hr after run
1	Cold	0.266	198	180	165	145	53.3
2	Hot	0.188	195	162	154	137	63.5
3	Hot	0.191	190	168	164	149	63.5
4	Hot	0.192	188	165	158	141	63.5
5	Hot	0.194	184	165	157	141	63.5
6	Hot	0.182	184	166	161	141	63.5
7	Hot	0.186	181	162	154	137	63.5
8	Hot	0.188	182	163	156	140	63.5
Avg.	Hot	0.189	186	164	158	141	63.5

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	-	-	28	28	27	-	-
Intake Air	40	45	43	42	43	47	53
Engine Water	62	55	49	53	64	80	84
Engine Oil	80	80	85	85	90	98	104
Exh. Man.	146	141	158	170	205	258	328
Before Comb.	130	130	150	164	201	254	326
After Comb.	156	132	142	148	179	228	290
Pressures, mm Hg							
Before Comb.	5.1	10.2	15.2	20.3	40.6	66.9	96.5
ΔP	10.2	10.2	15.2	20.3	40.6	66.0	96.5
After Comb.	Neg.	0	0	0	0	0.6	0.9
Before HCC-137	5.1	10.2	15.2	20.3	38.1	66.0	96.5
ΔP	2.5	2.5	2.5	2.5	10.2	15.2	17.8
After HCC-137	2.4	8.2	13.0	17.8	33.2	53.2	15.6
Before TAV_s	2.5	10.2	12.7	17.8	33.0	53.3	81.3
ΔP	2.5	10.2	12.7	17.8	33.0	53.3	81.3
After TAV_s	0	0	0	0	0	0.9	2.8

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[1] After 5 minute, 80.4 km/hr warmup

TABLE C-16. PARTICULATE TRAP EVALUATION DATA

Date: 2/18/76

Description of Item: Factory Mufflers, Second Baseline in Standard Stock Configuration

			Avg. Temperatures, °C			
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Muffler No. 1 Inlet	Muffler No. 1 Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.307	186	168	147	11.6
2	Hot	0.247	188	163	145	11.9
3	Hot	0.257	185	162	144	11.6
4	Hot	0.253	184	161	142	11.6
5	Hot	0.261	186	163	144	11.6
6	Hot	0.256	188	165	147	11.6
7	Hot	0.278	180	160	140	11.6
8	Hot	0.260	181	161	141	11.6
9	Hot	0.276	187	169	146	11.6
10	Hot	0.276	183	164	145	11.6
Avg.	Hot	0.263	187	163	144	11.6

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	25	25	26	26	27	26	26
Intake Air	45	37	37	39	40	46	50
Engine Water	42	39	43	47	52	65	79
Engine Oil	76	78	82	86	89	87	103
Exhaust Manifold	112	120	144	165	212	248	316
Before Muffler	85	103	129	148	188	236	300
After Muffler	80	92	115	132	168	212	272
Pressures, mm Hg							
Before Muffler No. 1	0.9	2.8	6.0	6.5	14.0	23.3	34.5
ΔP	0.9	2.4	4.1	4.3	7.3	11.6	17.4
After Muffler No. 1	0	0.4	2.0	2.2	5.8	10.5	16.2

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-17. PARTICULATE TRAP EVALUATION DATA

Date: 2/20/76
Description of Combination: Ethyl Agglomerator and Ethyl TAV single

Run No.	Type Test	Particulate g/km	Average Temperatures, °C Exhaust Manifold	 Agg. Inlet	 Between Units	 TAV_s Outlet	System ΔP, mmHg at 80.4 km/hr after run
1	Hot	0.250	211	175	157	146	106.7
2	Hot	0.256	210	195	181	171	111.8
3	Hot	0.277	214	181	161	150	111.8
4	Hot	0.288	200	174	158	147	116.8
5	Hot	0.255	196	168	157	148	114.3
6	Hot	0.268	201	168	155	145	109.2
7	Hot	0.278	202	173	159	149	109.2
8	Hot	0.275	200	168	154	144	109.2
9	Hot	0.291	194	171	153	136	106.7
Avg.	Hot	0.271	203	175	159	148	110.6

Steady State Pressures and Temperatures

	Speed, kph 0	 16.1	 32.2	 48.3	 64.4	 80.4	 96.5
				Temperatures, °C(1)			
Ambient Air	23	23	23	23	23	23	23
Intake Air	28	25	27	29	32	34	38
Engine Water	56	36	32	38	46	58	78
Engine Oil	81	78	81	83	87	93	101
Exhaust Man.	146	144	160	188	220	276	344
Before Agg.	118	124	145	170	202	260	335
Before TAV_s	130	115	122	138	168	212	275
				Pressures, mm Hg			
Before Agg.	2.5	20.3	33.0	38.5	76.2	123.0	177.8
ΔP	3.8	20.3	33.0	38.5	73.6	114.3	170.2
After TAV_s	Neg	0	0	0.2	1.7	3.9	7.1

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-18. PARTICULATE TRAP EVALUATION DATA

Date: 2/23/76

Description of Item: HCC-115 Agglomerator-Separator-Trap
"all in one" trap system

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Trap Inlet	Trap Outlet	at 80.4 km/hr after run
1	Cold	0.390	211	173	137	104.1
2	Hot	0.262	211	173	136	101.6
3	Hot	0.242	211	171	137	101.6
4	Hot	0.232	-	-	-	104.1
5	Hot	0.220	202	163	127	106.7
6	Hot	0.228	208	167	134	106.7
7	Hot	0.224	206	166	-	106.7
8	Hot	0.230	200	164	124	106.7
9	Hot	0.229	204	166	128	106.7
10	Hot	0.238	201	165	126	106.7
Avg.	Hot	0.234	205	167	130	105.3

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	25	25	24	24	24	24	24
Intake Air	51	62	57	46	45	48	54
Engine Water	76	79	69	59	59	71	82
Engine Oil	101	97	97	96	96	99	105
Exhaust Manifold	184	136	180	196	234	288	372
Before Trap	135	138	149	165	202	260	338
After Trap	160	130	120	125	150	192	258
Pressures, mm Hg							
Before Trap	7.6	22.9	38.1	43.2	81.3	127.0	185.4
ΔP	10.2	20.3	35.6	40.6	71.1	106.7	157.5
After Trap	Neg.	2.8	5.0	5.9	11.6	19.0	27.8

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-19. PARTICULATE TRAP EVALUATION DATA

Date: 2/24/76
Description of Item:HCC-115A Agglomerator-Separator - "all in one" trap system

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Trap Inlet	Trap Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.228	207	174	130	134.6
2	Hot	0.206	211	171	133	132.1
3	Hot	0.216	206	168	124	129.5
4	Hot	0.215	208	169	129	129.5
5	Hot	0.216	204	168	124	132.1
6	Hot	0.216	207	170	128	132.1
7	Hot	0.210	204	168	124	132.1
8	Hot	0.202	208	170	128	134.6
9	Hot	0.210	205	167	129	137.1
10	Hot	0.222	219	181	143	137.1
Avg.	Hot	0.211	208	170	129	132.9

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	22	22	21	21	22	22	22
Intake Air	42	35	35	37	41	45	51
Engine Water	46	39	43	47	56	70	82
Engine Oil	91	90	90	91	94	99	104
Exhaust Manifold	132	116	152	176	220	280	356
Before Trap	78	100	125	150	195	252	330
After Trap	88	85	95	110	142	142	255
Pressures, mm Hg							
Before Trap	5.1	27.9	48.3	55.9	99.1	147.3	215.9
ΔP	7.6	25.4	45.7	50.8	71.1	137.1	193.0
After Trap	Neg	2.2	4.1	4.7	9.7	15.9	23.4

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-20. PARTICULATE TRAP EVALUATION DATA

Date: 2/24 and 2/25/76
Description of Item: HCC-125 Agglomerator-Separator "all in one" trap system

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C			System ΔP, mm Hg at 80.4 km/hr after run
			Exhaust Manifold	Trap Inlet	Trap Outlet	
1	Hot	0.284	196	166	97	29.5
2	Hot	0.246	194	162	126	29.3
3	Cold	0.297	195	164	122	29.5
4	Hot	0.236	203	164	147	29.5
5	Hot	0.242	200	164	145	29.9
6	Hot	0.238	192	160	131	29.9
7	Hot	0.240	193	161	129	29.9
8	Hot	0.236	197	163	134	29.9
9	Hot	0.240	193	161	130	29.9
10	Hot	0.250	191	161	131	29.9
11	Hot	0.246	183	161	131	29.9
12	Hot	0.240	178	163	-	29.9
13	Hot	0.253	195	164	133	29.9
14	Hot	0.243	185	163	132	29.7
15	Hot	0.248	180	163	133	29.9
Avg.	Hot	0.246	191	162	131	29.8

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	23	22	23	23	23	22	22
Intake Air	39	36	37	37	39	41	46
Engine Water	43	38	46	48	49	59	77
Engine Oil	90	89	90	91	93	97	101
Exhaust Manifold	139	140	155	180	216	260	320
Before Trap	75	105	128	152	190	242	305
After Trap	100	99	110	118	132	156	188
Pressures, mm Hg							
Before Trap	0.2	8.9	11.2	11.7	20.5	34.0	43.0
ΔP	0	8.8	10.8	10.4	18.1	29.3	35.5
After Trap	0	0	0	0.9	2.1	4.3	6.7

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-21. PARTICULATE TRAP EVALUATION DATA

Date: 2/26/76

Description of Item: Texaco A-IF Agglomerator packed with alumina coated steel wool

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Trap Inlet	Trap Outlet	at 80.4 km/hr after run
1	Cold	0.256	202	150	146	22.4
2	Hot	0.205	204	162	166	22.4
3	Hot	0.208	195	154	155	24.3
4	Hot	0.201	201	160	164	24.3
5	Hot	0.210	192	156	158	24.3
6	Hot	0.207	201	161	164	24.3
7	Hot	0.214	197	156	158	24.3
8	Hot	0.212	197	157	161	24.3
9	Hot	0.204	194	-	163	24.3
10	Hot	0.224	188	162	161	24.3
Avg.	Hot	0.209	197	159	161	24.1

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	24	24	24	24	24	24	24
Intake Air	41	31	34	36	40	44	49
Engine Water	44	37	42	46	55	69	81
Engine Oil	90	88	89	92	95	99	104
Exhaust Manifold	122	130	148	176	216	260	312
Before Trap	80	89	110	132	178	225	278
After Trap	108	100	110	128	170	222	278
Pressures, mm Hg							
Before Trap	1.8	9.3	13.1	14.9	24.3	35.5	50.4
ΔP	0.9	3.7	7.5	9.3	16.8	26.1	39.2
After Trap	0	2.8	4.7	4.7	6.5	8.4	11.2

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-22. PARTICULATE TRAP EVALUATION DATA

Date: 2/27/76

Description of Combination: Texaco A-IF and Texaco A-IR Agglomerators

			Average Temperatures, °C				System ΔP,
Run No.	Type Test	Particulate g/km	Exhaust Manifold	A-IF Inlet	Between Traps	A-IR Outlet	mm Hg at 80.4 km/hr after run
1	Cold	0.176	197	160	149	132	71.0
2	Hot	0.093	196	---	---	---	71.0
3	Hot	0.094	194	156	148	138	72.8
4	Hot	0.092	196	166	161	153	74.7
5	Hot	0.097	195	161	155	145	76.6
6	Hot	0.106	197	166	161	153	76.6
7	Hot	0.095	197	160	151	141	76.6
8	Hot	0.104	196	163	156	147	76.6
9	Hot	0.101	195	162	155	145	76.6
10	Hot	0.110	197	163	158	149	76.6
Avg.	Hot	0.099	196	162	157	146	75.3

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperature, °C[1]							
Ambient	22	22	23	23	24	23	24
Intake Air	36	31	30	32	34	39	44
Engine Water	44	37	37	40	46	63	78
Engine Oil	90	89	88	89	92	97	103
Exhaust Man.	104	116	140	172	212	268	340
Before A-IF	70	86	112	138	178	230	296
After A-IR	110	95	98	110	142	190	250
Pressures, mm Hg							
Before Comb.	9.3	20.5	28.0	31.7	56.0	84.0	121.4
ΔP	5.6	16.8	26.1	29.9	52.3	82.2	117.7
After Comb.	2.8	3.7	3.7	2.8	2.8	2.2	4.1
Before A-IF	6.9	24.3	33.6	39.2	65.3	100.8	145.7
ΔP	1.8	5.6	5.6	14.9	18.7	28.0	56.0
After A-IF	4.8	16.8	26.2	26.2	50.4	72.8	97.1
Before A-IR	7.5	18.7	24.3	26.2	44.8	67.2	95.3
ΔP	3.7	14.9	20.5	22.4	39.2	59.8	87.8
After A-IR	2.8	2.8	2.8	2.8	3.7	4.7	6.5

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-23. PARTICULATE TRAP EVALUATION DATA

Date: 3/2/76

Description of Combination: HCC-137 packed bed Agglomerator(1)
and Ethyl TAV single separator

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	HCC-137 Inlet	TAV$_s$ Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.350	195	175	136	114.3
2	Hot	0.226	188	166	152	114.3
3	Hot	0.230	190	170	150	111.8
4	Hot	0.234	183	164	137	111.8
5	Hot	0.237	185	165	142	111.8
6	Hot	0.231	188	168	146	114.3
7	Hot	0.239	184	166	142	116.8
Avg.	Hot	0.233	186	166	144	113.5

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(2)							
Ambient Air	25	25	25	25	25	25	25
Intake Air	37	36	33	33	35	38	41
Engine Water	60	50	43	46	51	66	79
Engine Oil	87	87	87	88	90	96	101
Exhaust Manifold	128	132	140	164	196	252	324
Before HCC-137	102	102	128	148	188	240	313
After TAV$_s$	145	122	112	115	138	178	235
Pressures, mm Hg							
Before Combination	7.6	25.4	38.1	43.6	76.2	119.4	180.3
ΔP	7.6	25.4	38.1	40.6	75.2	116.8	172.7
After Combination	0	0	0	0.4	1.5	3.3	6.0
Before HCC-137	7.6	25.4	40.6	40.6	76.2	121.9	175.3
ΔP	5.1	2.5	7.6	7.6	12.7	20.3	25.4
After HCC-137	0.4	18.7	28.0	31.8	61.6	97.1	147.6
Before TAV$_s$	7.6	17.8	30.5	35.6	38.1	101.6	150.0
ΔP	7.6	18.0	30.5	35.6	35.6	104.1	147.3
After TAV$_s$	0	0	0	0	6.5	3.4	5.6

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(1) Gas entering designated inlet

(2) After 5 minute, 80.4 km/hr warmup

TABLE C-24. PARTICULATE TRAP EVALUATION DATA

Date: 3/3/76

Description of Item: HCC-137 Packed Bed Agglomerator[1]

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Avg. Temperatures, °C HCC-137 Inlet	Avg. Temperatures, °C HCC-137 Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.334	201	167	153	20.5
2	Hot	0.262	205	172	166	20.5
3	Hot	0.265	202	162	156	20.5
4	Hot	0.260	202	-	159	20.5
5	Hot	0.266	199	-	163	20.5
6	Hot	0.262	197	161	-	20.5
7	Hot	0.277	199	163	-	20.5
Avg.	Hot	0.265	201	164	161	20.5

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[2]							
Ambient Air	24	24	24	24	24	24	24
Intake Air	47	56	57	53	54	46	50
Engine Water	68	79	75	65	72	72	82
Engine Oil	90	97	100	101	106	106	106
Exhaust Manifold	140	144	150	172	212	248	308
Before HCC-137	118	120	132	144	178	225	282
After HCC-137	150	132	125	120	140	172	218
Pressures, mm Hg							
Before HCC-137	1.8	2.8	6.5	7.5	14.0	24.3	34.6
ΔP	1.8	2.8	6.5	7.5	13.1	20.5	29.0
After HCC-137	0	0	0	0	0.9	3.7	6.5

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(1)Gas entering designated inlet

(2)After 5 minute, 80.4 km/hr warmup

TABLE C-25. PARTICULATE TRAP EVALUATION DATA

Date: 3/4/76
Description of Item: Ethyl Dual Anchored TAV

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	TAV Inlet	TAV Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.342	201	171	130	33.6
2	Hot	0.264	200	162	124	33.6
3	Hot	0.261	211	171	136	33.6
4	Hot	0.268	208	169	132	31.8
5	Hot	0.258	208	169	134	33.6
6	Hot	0.270	206	166	131	33.6
Avg.	Hot	0.264	207	167	131	33.2

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	24	24	24	24
Intake Air	51	45	44	45	50	54	60
Engine Water	67	55	52	56	69	79	85
Engine Oil	91	89	90	92	96	99	103
Exhaust Manifold	144	142	152	180	208	256	328
Before TAV_2	100	108	122	148	182	235	302
After TAV_2	100	96	95	105	132	165	230
Pressures, mm Hg							
Before TAV_2	0.9	6.5	9.5	18.9	22.4	37.4	57.9
ΔP	2.8	7.5	12.1	19.4	22.6	35.5	50.4
After TAV_2	neg	neg	neg	neg	0	3.7	6.2

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-26. PARTICULATE TRAP EVALUATION DATA

Date: 3/5/76

Description of Item: Factory Mufflers, Third Baseline in Standard Stock Configuration

			Avg. Temperatures, °C			
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Muffler No. 1 Inlet	Muffler No. 1 Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.418	196	175	154	14.0
2	Hot	0.270	198	172	153	14.0
3	Hot	0.295	199	174	150	14.0
4	Hot	0.306	202	174	152	14.0
5	Hot	0.286	186	162	141	14.0
6	Hot	0.281	187	167	149	14.2
7	Hot	0.316	183	163	143	14.2
Avg.	Hot	0.292	192	169	148	14.1

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	22	23	22	22	22	22	22
Intake Air	46	43	40	39	40	42	47
Engine Water	64	62	49	51	55	69	80
Engine Oil	100	97	94	94	95	97	103
Exhaust Manifold	155	140	152	168	204	248	304
Before First Muffler	122	116	134	152	192	240	300
After First Muffler	115	105	115	130	162	210	262
Pressures, mm Hg							
Before First Muffler	0.9	2.8	6.2	6.5	13.1	23.4	35.1
ΔP	0.9	2.8	4.3	4.7	8.4	13.4	19.6
After First Muffler	0	0	1.9	1.9	6.5	10.8	17.0

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-27. PARTICULATE TRAP EVALUATION DATA

Date: 3-8-76

Description of Combination: Texaco A-IF Agglomerator and Ethyl TAV Separator, single

Run No.	Type Test	Particulate g/km	Average Temperatures, °C				System ΔP, mmHg at 80.4 km/hr after run
			Exhaust Manifold	A-IF Inlet	Between Units	TAV_s Outlet	
1	Cold	0.258	203	169	151	134	104.1
2	Hot	0.182	201	166	159	146	104.1
3	Hot	0.178	202	165	155	141	101.6
4	Hot	0.176	198	169	161	148	101.6
5	Hot	0.184	200	164	153	139	106.7
6	Hot	0.177	202	168	160	147	106.7
7	Hot	0.178	200	165	156	142	106.7
Avg.	Hot	0.179	200	166	157	144	104.6

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	24	24	24	24
Intake Air	44	53	47	40	41	44	48
Engine Water	67	62	56	55	59	71	82
Engine Oil	96	94	93	93	94	98	103
Exhaust Man.	162	152	160	180	220	268	336
Before A-IF	122	122	130	142	178	230	298
After TAVs	132	122	114	118	142	178	232
Pressures, mm Hg							
Before Com.	7.6	22.9	35.6	43.2	76.2	116.8	167.6
ΔP	7.6	22.9	35.6	43.2	71.1	111.8	162.6
After Comb.	0	0	0	0.2	2.0	4.5	7.6
Before A-IF	5.1	25.4	38.1	43.2	76.2	119.4	167.6
ΔP	2.5	7.6	10.2	10.2	17.8	27.9	35.6
After A-IF	3.7	16.8	30.1	30.1	57.0	88.8	128.9
Before TAV_s	2.5	15.2	25.4	30.5	55.9	88.9	132.1
ΔP	2.5	15.2	25.4	30.5	55.9	83.8	124.5
After TAV_s	0	0	0	0	0	1.9	3.0

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(1) After 5 minute, 80.4 km/hr warm up

TABLE C-28. PARTICULATE TRAP EVALUATION DATA

Date: 3-09-76

Description of Combination: Texaco A-IF Agglomerator, Texaco A-IR Agglomerator and Ethyl Anchored TAV, single.

Run No.	Type Test	Particulate g/km	Average Temperatures, °C: Exhaust Manifold	A-IF Inlet	A-IR Inlet	TAV_s Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.113	198	172	141	107	142.2
2	Hot	0.094	205	165	147	121	147.3
3	Hot	0.093	203	162	144	119	147.3
4	Hot	0.085	206	164	142	115	144.8
5	Hot	0.090	200	163	146	120	147.3
6	Hot	0.089	199	166	151	126	147.3
7	Hot	0.090	203	163	145	119	147.3
8	Hot	0.088	204	163	145	118	147.3
9	Hot	0.099	200	164	147	122	149.9
10	Hot	0.096	205	164	146	121	152.4
Average, Hot		0.092	202	164	146	120	147.8

Steady State Pressures and Temperatures

	Speed, kph: 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	24	24		25	24	25	24
Intake Air	45	52	49	47	48	49	48
Engine Water	73	72	62	59	64	77	80
Engine Oil	94	92	92	92	94	98	102
Exhaust Man.	140	136	144	168	208	264	328
Before A-IF	118	115	130	152	195	238	290
Before A-IR	135	118	115	125	158	195	242
Before TAV	150	142	125	122	138	170	208
After TAV	130	128	92	115	125	150	185
Pressures, mm Hg							
Before Comb.	12.7	38.1	55.9	61.0	104.1	160.0	218.4
ΔP	12.7	38.1	55.9	61.0	101.6	157.5	213.4
After Comb.	0	0	0	0	1.3	3.4	5.8
Before A-IF	12.7	40.6	55.9	61.0	109.2	160.0	218.4
ΔP	2.5	7.6	10.2	12.7	20.3	30.5	35.6
After A-IF	11.2	29.9	44.8	46.7	82.2	127.0	177.5
Before A-IR	7.6	30.5	45.7	50.8	86.4	132.1	185.4
ΔP	5.1	12.7	20.3	20.3	35.6	50.8	71.1
After A-IR	3.7	16.8	24.3	28.0	48.6	72.8	104.6
Before TAV_s	2.5	15.2	25.4	27.9	50.8	78.7	114.3
ΔP	2.5	15.2	25.4	27.9	50.8	76.2	106.7
After TAV_s	0	0	0	0	0	3.7	6.2

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(1) After 5 minute, 80.4 km/hr warm up

TABLE C-29. PARTICULATE TRAP EVALUATION DATA

Date: 4/27/76
Description of Item: Factory Mufflers, Fourth Baseline, in Standard Stock Configuration

			Avg. Temperatures, °C			
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Muffler No. 1 Inlet	Muffler No. 1 Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.260	205	186	165	12.7
2	Hot	0.298	199	179	160	12.7
3	Hot	0.316	198	176	157	12.1
4	Hot	0.314	202	180	152	12.1
5	Hot	0.317	197	177	159	12.5
6	Hot	0.312	201	179	152	12.1
7	Hot	0.323	200	180	152	12.1
8	Hot	0.309	201	179	161	12.1
Avg.	Hot	0.313	200	179	156	12.2

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C [1]							
Ambient Air	27	26	26	25	25	25	26
Intake Air	44	48	42	40	40	44	48
Engine Water	65	65	53	52	58	72	81
Engine Oil	93	92	92	92	94	97	103
Exhaust Manifold	172	168	176	200	230	280	332
Before First Muffler	160	152	164	180	220	276	328
After First Muffler	156	148	148	160	192	240	296
Pressures, mm Hg							
Before First Muffler	0.9	3.4	6.2	7.3	13.6	23.0	35.1
ΔP	0.9	2.4	3.7	4.1	7.8	12.1	18.9
After First Muffler	0	0.9	1.8	2.4	5.8	9.9	15.3

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[1] After 5 minute, 80.4 km/hr warmup

TABLE C-30. PARTICULATE TRAP EVALUATION DATA

Date: 4/29/76
Description of Item: Texaco A-IRpacked with steel wool only, no alumina coating

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Trap Inlet	Trap Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.248	196	146	151	14.0
2	Hot	0.205	189	141	146	14.0
3	Hot	0.205	190	145	150	14.0
4	Hot	0.205	188	144	149	16.8
5	Hot	0.210	188	145	151	17.7
6	Hot	0.197	190	152	157	17.7
7	Hot	0.198	194	151	156	18.6
8	Hot	0.188	199	155	160	19.0
Avg.	Hot	0.201	191	148	153	16.8

Steady State Temperatures and Pressures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	24	25	26	26
Intake Air	48	43	40	40	43	46	50
Engine Water	71	60	52	53	64	76	83
Engine Oil	97	94	93	93	95	98	104
Exhaust Manifold	188	174	180	200	230	280	340
Before Trap	148	134	140	158	189	235	290
After Trap	148	134	140	158	189	239	296
Pressures, mm Hg							
Before Trap	0.9	5.2	8.4	9.3	16.4	26.5	38.8
ΔP	0.9	4.7	7.5	8.4	14.0	21.5	30.8
After Trap	0	0	0	0.9	2.4	4.7	7.1

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-31. PARTICULATE TRAP EVALUATION DATA

Date: 5/3/76

Description of Item: SwRI-Texaco A-IM Radial Separator Center Inlet, Inconel Mesh Annular Element Alumina Coated

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C			System ΔP, mm Hg at 80.4 km/hr after run
			Exhaust Manifold	Trap Inlet	Trap Outlet	
1	Cold	0.376	203	179	165	30.8
2	Hot	0.255	204	177	169	30.8
3	Hot	0.269	179	162	153	30.8
4	Hot	0.260	173	158	150	30.8
5	Hot	0.273	173	158	150	30.8
6	Hot	0.265	191	167	160	30.8
7	Hot	0.276	187	167	158	30.8
8	Hot	0.261	190	168	160	30.8
Avg.	Hot	0.266	186	165	157	30.8

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	32	25	24	23	23	23	23
Intake Air	44	48	41	37	37	40	44
Engine Water	70	69	53	49	55	68	79
Engine Oil	92	92	92	92	93	96	101
Exhaust Manifold	180	172	179	205	227	276	324
Before Trap	150	144	156	171	206	258	300
After Trap	158	144	148	158	190	238	292
Pressures, mm Hg							
Before Trap	0.9	6.5	10.8	12.1	23.3	38.3	57.9
ΔP	0.9	4.7	8.4	9.3	17.7	29.9	46.7
After Trap	0	0.9	0.9	1.7	3.7	7.1	10.8

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-32. PARTICULATE TRAP EVALUATION DATA

Date: 5/4/76

Description of Item: SwRI-Texaco A-IM Radial Separator, Outershell Inlet

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Trap Inlet	Trap Outlet	at 80.4 km/hr after run
1	Cold	0.318	196	178	163	48.6
2	Hot	0.289	190	162	159	48.6
3	Hot	0.293	190	164	158	49.5
4	Hot	0.298	189	-	155	48.6
5	Hot	0.325	189	167	148	48.1
6	Hot	0.308	189	174	165	48.6
7	Hot	0.312	188	163	148	48.6
8	Hot	0.309	182	168	155	48.6
Avg.	Hot	0.305	188	166	155	48.6

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	27	26	24	24	24	24	24
Intake Air	44	47	49	37	37	39	43
Engine Water	69	68	56	50	56	64	77
Engine Oil	93	92	92	92	93	96	100
Exhaust Manifold	180	172	180	196	226	276	336
Before Trap	150	146	160	175	212	266	330
After Trap	170	148	146	156	185	235	295
Pressures, mm Hg							
Before Trap	1.8	6.5	14.9	22.4	29.9	50.4	80.3
ΔP	1.8	6.5	14.9	22.4	29.5	48.6	72.8
After Trap	0	0	0	0	2.2	5.2	8.9

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-33. PARTICULATE TRAP EVALUATION DATA

Date: 5/5/76

Description of Item: HCC-137 Radial Agglomerator, with 9.5mm (3/8 inch) diameter HCC, alumina spheres

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Trap Inlet	Trap Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.399	195	180	146	23.4
2	Hot	0.297	193	176	162	23.3
3	Hot	0.306	183	170	152	22.4
4	Hot	0.295	184	170	159	22.4
5	Hot	0.298	178	158	149	22.4
6	Hot	0.310	183	169	157	22.4
7	Hot	0.318	178	166	148	22.4
8	Hot	0.315	185	163	159	22.4
Avg.	Hot	0.305	183	167	152	22.4

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	34	29	29	28	28	27	28
Intake Air	46	51	47	48	43	46	49
Engine Water	70	70	62	57	62	73	82
Engine Oil	92	92	92	92	92	97	102
Exhaust Manifold	172	172	180	200	238	276	336
Before Trap	145	148	162	175	218	250	335
After Trap	168	150	152	159	198	225	280
Pressures, mm Hg							
Before Trap	1.7	4.3	6.5	8.4	16.8	28.9	44.0
ΔP	1.7	4.3	6.5	7.9	13.4	22.4	32.7
After Trap	0	0	0	0.9	2.4	5.2	8.4

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[1] After 5 minute, 80.4 km/hr warmup

TABLE C-34. PARTICULATE TRAP EVALUATION DATA

Date: 5/6/76

Description of Item: HCC-137 Radial Agglomerator with 4.8mm (3/16 inch) diameter HCC, alumina spheres

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	HCC-137 Inlet	HCC-137 Outlet	at 80.4 km/hr after run
1	Cold	0.341	183	172	138	22.0
2	Hot	0.304	184	170	157	22.4
3	Hot	0.312	178	167	150	22.9
4	Hot	0.303	184	170	158	22.8
5	Hot	0.298	177	164	149	22.8
6	Hot	0.296	180	166	153	22.8
7	Hot	0.307	176	160	148	22.8
8	Hot	0.295	181	166	157	22.8
Avg.	Hot	0.302	180	166	153	22.8

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	34	34	28	27	27	27	27
Intake Air	48	51	50	48	43	43	45
Engine Water	79	77	70	57	62	74	82
Engine Oil	94	93	92	91	92	95	100
Exhaust Manifold	164	162	164	180	220	268	324
Before HCC-137	140	135	152	168	212	255	310
After HCC-137	175	145	140	148	178	225	275
Pressures, mm Hg							
Before HCC-137	1.8	4.6	7.5	8.4	17.0	28.6	41.6
ΔP	1.8	4.6	7.5	7.8	13.6	23.0	31.8
After HCC-137	0	0	0.4	0.6	2.4	5.2	8.4

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-35. PARTICULATE TRAP EVALUATION DATA

Date: 5/6/76
Description of Item: HCC Mini-Swirl Tube Separator

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Separator Inlet	Separator Outlet	at 80.4 km/hr after run
1	Hot	0.262	189	155	148	66.0
2	Hot	0.285	205	165	159	66.0
3	Hot	0.294	202	163	156	66.0
4	Hot	0.307	203	165	158	66.0
Avg.		0.295	200	162	155	66.0

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
				Temperatures, °C[1]			
Ambient Air	25	24	24	24	24	25	25
Intake Air	47	54	50	44	43	46	52
Engine Water	64	62	57	57	59	72	81
Engine Oil	89	89	89	90	90	96	101
Exhaust Manifold	172	168	180	200	236	292	350
Before Separator	142	138	152	165	200	248	316
After Separator	140	132	142	155	186	235	298
				Pressures, mm Hg			
Before Separator	5.0	12.7	20.3	22.9	43.2	68.6	111.8
ΔP	5.0	12.7	20.3	22.9	40.6	66.0	101.6
After Separator	0	0	0.4	0.6	2.8	5.8	8.9

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[1] After 5 minute, 80.4 km/hr warmup

TABLE C-36. PARTICULATE TRAP EVALUATION DATA

Date: 5/7/76

Description of Item: Factory Mufflers, Fifth Baseline, in Standard Stock Configuration

			Avg. Temperatures, °C			
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Muffler No. 1 Inlet	Muffler No. 1 Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.351	200	180	158	12.1
2	Hot	0.307	194	183	156	12.1
3	Hot	0.318	186	169	152	12.1
4	Hot	0.312	189	170	154	12.1
5	Hot	0.333	187	169	152	12.1
6	Hot	0.322	188	169	153	11.9
7	Hot	0.346	189	170	154	11.9
8	Hot	0.350	193	174	158	11.9
Avg.	Hot	0.327	189	172	154	12.0

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	25	24	24	24
Intake Air	48	50	44	46	46	44	72
Engine Water	74	73	57	56	60	72	81
Engine Oil	92	92	92	92	93	96	101
Exhaust Manifold	180	168	172	190	224	290	328
Before First Muffler	150	145	155	170	210	262	327
After First Muffler	145	135	140	150	185	230	288
Pressures, mm Hg							
Before First Muffler	0.9	3.4	6.2	7.1	13.6	22.4	34.6
ΔP	0.9	2.8	4.3	4.7	7.6	12.7	18.3
After First Muffler	0	0.6	1.9	2.4	5.2	9.5	14.0

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-37. PARTICULATE TRAP EVALUATION DATA

Date: 5/10/76

Description of Item: Texaco A-IR Agglomerator shell filled with 9.5mm (3/8 inch) diameter HCC alumina spheres

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Agg. Inlet	Agg. Outlet	at 80.4 km/hr after run
1	Cold	0.457	202	166	89	86.4
2	Hot	0.313	208	166	149	83.8
3	Hot	0.282	201	163	138	83.8
4	Hot	0.254	207	165	150	83.8
5	Hot	0.249	200	162	140	83.8
6	Hot	0.245	207	167	150	83.8
7	Hot	0.242	199	162	138	83.8
8	Hot	0.232	208	169	152	83.8
Avg.	Hot	0.259	204	165	145	83.8

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	23	22	23	23	23	23	23
Intake Air	49	60	49	48	44	45	50
Engine Water	75	79	65	58	64	77	83
Engine Oil	103	102	99	93	94	97	103
Exhaust Manifold	196	184	188	212	240	292	360
Before Trap	155	148	155	172	200	250	300
After Trap	165	178	182	165	160	170	188
Pressures, mm Hg							
Before Trap	7.6	22.9	35.6	38.1	70.0	94.0	132.0
ΔP	7.6	20.3	33.0	35.6	53.3	83.8	121.9
After Trap	0	0.6	2.4	5.0	6.7	10.6	8.3

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[1] After 5 minute, 80.4 km/hr warmup

TABLE C-38. PARTICULATE TRAP EVALUATION DATA

Date: 5/11/76
Description of Item: TexacoA-IR Agglomerator shell filled with 4.8mm (3/16 inch) diameter HCC alumina spheres

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Agg. Inlet	Agg. Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.217	208	170	83	160.0
2	Hot	0.188	216	171	145	144.8
3	Hot	0.250	214	170	143	149.9
4	Hot	0.252	209	179	144	154.9
5	Hot	0.240	190	164	145	152.4
6	Hot	0.232	192	167	145	154.9
7	Hot	0.238	188	162	139	154.9
8	Hot	0.225	189	163	142	154.9
Avg.	Hot	0.232	200	168	143	152.4

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	25	25	25	25	25	25
Intake Air	49	54	49	45	44	48	104
Engine Water	78	77	67	62	66	78	84
Engine Oil	96	93	93	92	93	96	102
Exhaust Manifold	196	180	186	203	244	300	380
Before Trap	170	155	160	175	201	250	322
After Trap	178	188	182	172	164	168	215
Pressures, mm Hg							
Before Trap	15.2	35.6	50.8	58.4	111.8	175.2	259.0
ΔP	15.2	33.0	48.2	55.9	106.7	165.1	238.8
After Trap	0	0.9	2.8	3.4	6.9	10.8	16.2

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[1] After 5 minute, 80.4 km/hr warmup

TABLE C-39. PARTICULATE TRAP EVALUATION DATA

Date: 5-12-76
Description of Combination: Texaco A-IR, packed with alumina coated steel Agglomerator and HCC Mini-swirl tube separator.

Run No.	Type Test	Particulate g/km	Average Temperatures, °C				System ΔP, mm Hg at 80.4 km/hr after ru
			Exhaust Manifold	A-IR Outlet	A-IR Inlet	HC Outlet	
1	Cold	0.372	214	165	150	131	104.1
2	Hot	0.189	207	172	166	148	101.6
3	Hot	0.182	206	163	161	144	101.6
4	Hot	0.184	204	165	162	145	101.6
5	Hot	0.192	202	159	153	136	101.6
6	Hot	0.181	205	164	161	144	101.6
7	Hot	0.184	209	166	163	146	104.1
8	Hot	0.190	206	171	170	154	104.1
Avg.	Hot	0.186	206	166	162	145	102.3

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.6
Temperatures, °C(1)							
Ambient Air	25	25	26	25	25	25	25
Intake Air	48	53	47	41	42	46	48
Engine Water	76	76	62	58	62	76	82
Engine Oil	97	93	93	92	93	97	102
Exhaust Man.	186	172	180	198	232	290	360
Before Comb.	150	141	151	165	202	254	320
After Comb.	122	155	142	148	165	202	255
Pressures, mm Hg							
Before Comb.	7.6	25.4	38.1	40.6	71.1	111.8	165.1
ΔP	7.6	25.4	38.1	40.6	68.7	109.2	154.9
After Comb.	0	0	0.4	0.7	3.0	5.6	9.5
Before A-IR	7.6	25.4	38.6	40.6	71.8	112.6	166.0
ΔP	2.1	12.5	16.7	17.4	27.9	41.7	52.9
After A-IR	5.2	12.6	21.0	22.9	43.0	70.2	112.8
Before Mini-Sw.	5.0	12.7	20.3	22.9	43.2	68.6	111.8
ΔP	5.0	12.7	20.3	22.9	40.6	66.0	101.6
After Mini-Swirl	0	0	0.4	0.6	2.8	5.8	9.3

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(1) After 5 minute, 80.4 km/hr warm up

TABLE C-40. PARTICULATE TRAP EVALUATION DATA

Date: 5/13 and 5/14/76
Description of Item: HCC Back Pack with Fine Filter Media

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Pack Inlet	Pack Outlet	at 80.4 km/hr after run
1	Hot	0.053	196	160	126	47.6
2	Hot	0.063	204	164	131	62.6
3	Hot	0.090	207	167	133	63.5
4	Hot	0.110	208	169	134	72.8
5	Hot	0.124	209	160	136	74.7
6	Cold	Test stopped after 16 minutes(1)				
7	Hot	0.198	214	171	131	78.7
8	Hot	0.197	198	162	111	78.7
9	Hot	0.217	200	164	128	78.7
Avg.	Hot	0.132	204	165	129	69.7

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(1) Exhaust pipe separated before back pack.

Steady State Conditions were not run.

TABLE C-41. PARTICULATE TRAP EVALUATION DATA

Date: 5/14 and 5/17/76
Description of Item:HCC Back Pack with Medium Filter Media

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C Exhaust Manifold	Pack Inlet	Pack Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Hot	0.072	206	166	130	49.5
2	Cold	0.100	206	168	133	65.4
3	Hot	0.142	205	169	134	68.6
4	Hot	0.171	206	170	136	71.1
5	Hot	0.187	200	166	132	73.7
6	Hot	0.199	196	163	129	73.7
7	Hot	0.206	190	159	120	73.7
8	Hot	0.216	191	159	121	73.7
Avg.	Hot	0.170	199	165	129	69.1

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	23	24	23	23
Intake Air	47	50	44	39	40	4	45
Engine Water	75	73	57	54	60	73	81
Engine Oil	96	94	93	92	93	96	101
Exhaust Manifold	184	176	180	198	232	282	340
Back Pack Inlet	152	143	150	162	200	252	315
Back Pack Outlet	167	145	134	134	150	190	232
Pressures, mm Hg							
Back Pack Inlet	7.6	17.8	25.4	27.9	48.3	76.2	101.6
ΔP	10.2	20.3	25.4	30.5	50.8	73.7	99.1
Back Pack Outlet	Neg.	Neg.	0	0	0.9	2.6	5.2

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-42. PARTICULATE TRAP EVALUATION DATA

Date: 5/18/76
Description of Item: HCC Back Pack with Coarse Filter Media

			Avg. Temperatures, °C			System ΔP, mm Hg at 80.4 km/hr after run
Run No.	Type Test	Particulate g/km	Exhaust Manifold	Pack Inlet	Pack Outlet	
1	Cold	0.270	192	163	126	17.7
2	Hot	0.238	192	159	130	16.6
3	Hot	0.227	193	161	133	17.7
4	Hot	0.228	194	161	137	17.7
5	Hot	0.216	188	156	124	17.7
6	Hot	0.217	194	163	141	18.1
7	Hot	0.212	193	161	133	18.5
8	Hot	0.222	196	165	138	18.9
9	Hot	0.215	195	164	139	19.0
Avg.	Hot	0.222	193	161	136	18.0

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	24	24	24	24	24	24	24
Intake Air	48	51	43	40	41	44	47
Engine Water	74	73	58	57	62	74	81
Engine Oil	96	93	93	92	94	97	102
Exhaust Manifold	180	172	177	194	226	280	328
Back Pack Inlet	146	140	150	160	198	250	302
Back Pack Outlet	162	140	130	131	150	182	225
Pressures, mm Hg							
Back Pack Inlet	1.8	4.6	7.1	8.9	14.9	22.4	35.3
ΔP	1.8	4.6	6.5	7.5	12.5	19.6	29.7
Back Pack Outlet	0	0	0	0.9	1.5	2.8	5.4

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-43. PARTICULATE TRAP EVALUATION DATA

Date: 5-20-76

Description of item: SwRI, Texaco A-IE, Axial Flow Cannister, packed with alumina coated steel wool.

Run No.	Type Test	Particulate g/km	Average Temp., °C Exhaust Manifold	Average Temp., °C Cannister Outlet	System ΔP mm Hg at 80.4 km/hr after run
1	Cold	0.256	179	189	88.9
2	Hot	0.178	184	191	91.4
3	Hot	0.190	179	179	91.4
4	Hot	0.216	183	184	91.4
5	Hot	0.220	178	178	94.0
6	Hot	0.326	179	180	96.5
7	Hot	0.312	176	176	91.4
8	Hot	0.270	182	172	91.4
9	Hot	0.265	181	183	91.4
Avg.	Hot	0.247	180	180	92.4

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.6
Temperatures, °C(1)							
Ambient Air	24	24	24	24	24	24	25
Intake Air	43	39	37	37	39	43	48
Engine Water	70	58	47	49	58	72	82
Engine Oil	92	88	88	88	91	95	101
Exhaust Man.	160	148	160	184	224	274*	348*
Cannister Out.	140	125	148	172	215	278*	352*
Pressures, mm Hg							
Cannister In.	7.6	22.9	35.6	40.6	68.6	106.7	152.4
ΔP	7.6	20.3	30.5	38.1	63.5	96.5	134.6
Cannister Out.	0	0.6	1.8	2.4	6.0	10.3	16.4

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(1) After 5 minute, 80.4 km/hr warmup

* Burn off may have occurred

TABLE C-44. PARTICULATE TRAP EVALUATION DATA

Date: 5-21-76

Description of Combination: Texaco A-IE Axial Flow Cannister and Texaco A-IR Alumina Steel Wool Coated Agglomerators

Run No.	Type Test	Particulate g/km	Average Temperatures, °C Exhaust Manifold	A-IE Outlet	A-IR Inlet	A-IR Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Cold	0.158	198	180	146	133	142.2
2	Hot	0.125	197	172	136	130	137.1
3	Hot	0.111	192	173	140	133	137.1
4	Hot	0.105	198	170	135	127	137.1
5	Hot	0.112	197	178	143	137	137.1
6	Hot	0.108	195	177	141	135	142.2
7	Hot	0.106	197	175	140	133	149.9
8	Hot	0.143	198	175	138	134	154.9
Avg.	Hot	0.116	196	174	139	133	142.2

Steady State Pressures and Temperatures

	Speed, kph 0	16.1	32.2	48.3	64.4	80.4	96.6
Temperatures, °C(1)							
Ambient Air	24	24	24	24	24	24	24
Intake Air	46	49	42	40	41	44	48
Engine Water	74	73	56	54	60	73	81
Engine Oil	93	92	92	92	93	96	101
Exhaust Man.	180	172	176	196	236	288	360
A-IE Outlet	188	150	152	174	218	275	350
A-IR Inlet	132	118	125	140	180	232	300
A-IR Outlet	172	135	125	128	158	200	260
Pressures, mm Hg							
Before Comb.	12.7	35.6	50.8	70.0	104.1	157.5	221.0
ΔP	15.2	38.1	50.8	70.0	101.6	155.9	215.9
After Comb.	Neg	Neg	0	0	1.5	3.9	6.7
Before A-IE	12.6	35.9	50.6	70.1	103.7	156.8	221.0
ΔP	7.5	23.3	35.2	50.0	67.7	103.0	143.1
After A-IE	5.1	12.9	15.5	20.1	35.0	54.0	79.0
Before A-IR	5.1	12.7	15.3	20.3	35.6	53.3	78.7
ΔP	5.1	10.2	15.3	20.3	33.0	48.3	71.7
After A-IR	0	0	0	0	1.5	3.9	5.7

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(1) After 5 minute, 80.4 km/hr warm up

TABLE C-45. PARTICULATE TRAP EVALUATION DATA

Date: 5-24-76
Description of Combination: Texaco A-IE, Axial Flow Cannister, Texaco A-IR and Ethyl TAV_s, Separator

			Average Temperature, °C					System mm Hg
Run No.	Type Test	Particulate g/km	Exhaust Manifold	A-IE Outlet	A-IR Inlet	A-IR Outlet	TAV_s Outlet	80. 4 km after r
1	Hot	0. 116	203	188	146	119	109	190. 5
2	Hot	0. 117	206	183	142	116	111	190. 5
3	Hot	0. 120	208	186	145	117	112	193.0
4	Hot	0. 116	207	177	138	109	104	190. 5
5	Hot	0. 112	211	188	144	112	107	190. 5
6	Hot	0. 114	210	189	146	116	111	193. 0
7	Hot	0. 116	214	187	146	117	112	198. 1
8	Hot	0. 118	214	190	146	120	115	200. 7
Avg.		0. 116	210	186	144	115	110	193. 7

Steady State Pressures and Temperatures

	Speed, kph						
	0	16. 1	32. 2	48. 3	64. 4	80. 4	96. 6
				Temperatures, °C(1)			
Ambient Air	25	25	25	25	25	25	25
Intake Air	47	44	42	41	43	47	51
Engine Water	75	67	55	55	66	76	83
Engine Oil	95	92	90	90	93	96	102
Exhaust Man.	184	172	182	202	240	304	376
A-IE Outlet	180	165	159	182	205	242	362
A-IR Inlet	140	115	130	148	188	240	305
A-IR Outlet	150	132	122	122	135	167	210
TAV_s Outlet	148	138	118	116	130	162	205
				Pressures, mm Hg(2)			
Before Comb.	15. 2	45. 7	71. 1	76. 2	132. 1	200. 7	284. 5
ΔP	15. 2	45. 7	71. 1	76. 2	132. 1	200. 7	284. 5
After Comb.	0	0	0	0	0	0. 4	1. 8

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(1) After 5 minute, 80. 4 km/hr warmup

(2) High Back Pressure, therefor only one steady state series was run

TABLE C-46. PARTICULATE TRAP EVALUATION DATA

Date: 5/26/76
Description of Item: Factory Mufflers, Sixth Baseline, in Standard Stock Configuration

Run No.	Type Test	Particulate g/km	Avg. Temperatures, °C			System ΔP, mm Hg at 80.4 km/hr after run
			Exhaust Manifold	Muffler No. 1 Inlet	Muffler No. 1 Outlet	
1	Hot	0.320	198	173	145	9.7
2	Hot	0.331	185	163	145	9.9
3	Hot	0.334	185	163	146	9.7
4	Hot	0.319	203	174	155	10.1
5	Hot	0.322	190	167	150	10.1
6	Hot	0.328	189	168	151	10.1
7	Hot	0.325	185	164	148	10.1
Avg.	Hot	0.326	191	167	149	10.0

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	30	30	30	31	31	31	31
Intake Air	48	54	51	46	47	48	53
Engine Water	73	76	66	60	66	76	84
Engine Oil	89	89	90	90	90	95	102
Exhaust Manifold	168	168	176	196	244	288	344
Before First Muffler	142	142	155	172	208	265	331
After First Muffler	135	128	138	152	182	232	288
Pressures, mm Hg							
Before First Muffler	0.4	1.5	3.7	4.7	11.6	19.2	30.4
ΔP	0.4	1.5	3.4	3.4	6.5	10.3	16.1
After First Muffler	0	0	0.9	1.3	4.8	9.0	14.0

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(1) After 5 minute, 80.4 km/hr warmup

TABLE C-47. PARTICULATE TRAP BACK PRESSURE

Date: 6-07-76

Description of item: Texaco A-IE Axial Flow Cannister, Restriction as Received and After Removal of one half of Coated Brillo packing.

	Inlet Restriction, mm Hg	
km/hr	As Received	After Packing Removed
0	7.6	5.1
16.1	22.9	15.2
32.2	35.6	25.4
48.3	40.6	30.5
64.4	68.6	48.2
80.4	106.7	78.7
96.6	152.4	111.8
	5/20/76	6/07/76

TABLE C-48. PARTICULATE TRAP EVALUATION DATA

Date: 6/9 and 6/10/76

Description of Combination: Texaco A-IF, A-IR and Ethyl TAV_s, under car. Exhaust pipe and A-IF insulated with 2 layers of fiberglass. EPA cooling fan only.

			Avg. Temperatures, °C			
Run No.	Type Test	Particulate g/km	A-IF Inlet	A-IR Inlet	TAV_s Outlet	System ΔP, mm Hg at 80.4 km/hr after run
1	Hot	0.200	204	198	175	177.3
2	Hot	0.157	225	201	180	177.3
3	Hot	0.160	217	190	168	177.5
4	Hot	0.154	225	200	177	177.3
5	Hot	0.161	221	196	175	177.3
6	Hot	0.160	232	209	190	179.9
7	Hot	0.164	220	195	173	182.4
8	Cold	0.182	213	179	149	185.0
Avg.	Hot	0.165	220	198	177	178.4

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C[1]							
Ambient Air	24	24	24	25	25	24	24
Intake Air	49	44	41	41	42	48	56
Engine Water	74	62	55	57	62	77	84
Engine Oil	99	95	92	92	93	97	103
Exhaust Manifold	187	176	182	210	254	316	419
A-IF Inlet	248	212	212	212	250	304	388
A-IF Outlet	272	230	208	209	238	290	367
A-IR Inlet	238	215	200	198	218	265	328
TAV_s Inlet	222	215	200	190	195	222	268
TAV_s Outlet	167	160	153	143	140	150	177
Pressures, mm Hg							
A-IF Inlet	15.2	50.8	71.1	78.7	129.5	188.0	254.0
A-IR Inlet	10.2	40.6	58.4	61.0	106.7	157.4	215.9
TAV_s Inlet	0.9	16.8	28.0	28.0	50.0	84.0	123.0
TAV_s Outlet	Neg	Neg	Neg	Neg	1.5	3.0	5.0

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(1)After 5 minute, 80.4 km/hr warmup

TABLE C-49. PARTICULATE TRAP EVALUATION DATA

Date: 6/10/76

Description of Combination: Texaco A-IF, A-IR and Ethyl TAV$_s$, under car. Not insulated, EPA Cooling fan only.

			Avg. Temperatures, °C			System ΔP, mm Hg
Run No.	Type Test	Particulate g/km	A-IF Inlet	A-IR Inlet	A-IR Outlet	at 80.4 km/hr after run
1	Hot	0.156	165	135	124	160.7
2	Hot	0.154	173	143	133	163.3
3	Hot	0.169	171	143	135	165.8
4	Hot	0.154	172	143	133	168.2
5	Hot	0.166	168	138	127	170.5
6	Hot	0.168	170	142	132	170.5
7	Hot	0.177	168	139	128	173.0
8	Hot	0.174	167	139	128	175.6
Avg.		0.165	169	140	130	168.4

Steady State Pressures and Temperatures

	Speed, kph						
	0	16.1	32.2	48.3	64.4	80.4	96.5
Temperatures, °C(1)							
Ambient Air	23	24	24	25	25	25	26
Intake Air	49	53	47	43	43	47	52
Engine Water	76	75	60	56	62	78	75
Engine Oil	94	92	92	90	92	97	103
Exhaust Manifold	190	174	179	208	256	322	424
A-IF Inlet	160	148	156	164	204	260	328
A-IF Outlet	185	160	158	158	190	242	335
A-IR Inlet	155	138	135	135	165	210	268
TAV$_s$ Inlet	160	148	138	130	140	175	220
TAV$_s$ Outlet	124	114	103	98	97	118	149
Pressures, mm Hg							
A-IF Inlet	15.2	43.1	61.0	71.1	119.4	182.9	246.4
A-IR Inlet	10.2	35.6	50.8	55.9	99.1	152.4	208.3
TAV$_s$ Inlet	0.9	13.1	24.3	25.2	46.7	76.6	113.9
TAV$_s$ Outlet	Neg.	Neg.	Neg.	Neg.	0.7	2.4	3.9

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(1) After 5 minute, 80.4 km/hr warmup

APPENDIX D

PARTICULATE AND SULFATE EMISSION RATES MERCEDES 300D WITH AND WITHOUT PARTICULATE TRAPPING SYSTEM

TABLE D-1. PARTICULATE AND SULFATE EMISSION RATES
MERCEDES 300D WITH PARTICULATE TRAP SYSTEM (47 mm FILTERS)

Test	Particulate Emission Rates						Sulfate Rates		
	Fluoropore			Fiberglass					
(Date)	g/km	g/hr	g/kg fuel	g/km	g/hr	g/kg fuel	mg/km	mg/hr	mg/kg fuel
1975 FTP									
(6/14/76)	0.150	4.727	1.442	0.211	6.629	2.007	2.210	69.428	20.8
(6/15/76)	0.158	4.953	1.380	0.189	5.939	1.655	1.008	31.874	8.8
(6/16/76)	0.156	4.924	1.414	0.194	6.086	1.763	1.022	32.121	9.3
Average	0.155	4.868	1.412	0.198	6.219	1.808	1.413	44.474	12.97
FTP_c									
(6/14/76)	0.160	5.025	1.402	0.257	8.073	2.265	3.150	98.983	28.00
(6/15/76)	0.161	5.041	1.340	0.186	5.862	1.558	1.218	38.753	10.22
(6/16/76)	0.186	5.846	1.533	0.217	6.838	1.794	1.221	38.369	10.12
Average	0.169	5.304	1.425	0.220	6.924	1.872	1.863	58.702	16.11
FTP_h									
(6/14/76)	0.143	4.503	1.472	0.176	5.539	1.812	1.500	47.133	15.45
(6/15/76)	0.156	4.886	1.411	0.191	5.998	1.729	0.849	26.685	7.70
(6/16/76)	0.134	4.229	1.325	0.176	5.518	1.740	0.872	27.407	8.62
Average	0.144	4.539	1.403	0.181	5.685	1.760	1.074	33.742	10.59
SET									
(6/14/76)	0.101	5.640	1.113	0.130	7.222	1.427	0.915	51.242	10.08
(6/15/76)	0.128	7.180	1.229	0.138	7.759	1.329	0.855	47.876	8.22
(6/16/76)	0.122	6.887	1.282	0.142	7.957	1.481	0.796	44.753	8.33
Average	0.117	6.569	1.208	0.137	7.646	1.412	0.855	47.957	8.88
FET									
(6/14/76)	0.074	5.739	0.762	0.109	8.466	1.122	0.663	51.454	8.29
(6/15/76)	0.106	8.227	1.010	0.121	9.374	1.149	0.606	47.031	5.79
(6/16/76)	0.113	7.799	1.172	0.131	10.145	1.366	0.655	51.019	6.88
Average	0.097	7.255	0.982	0.117	9.328	1.212	0.641	49.835	6.99

TABLE D-2. PARTICULATE AND SULFATE EMISSION RATES
MERCEDES 300D WITH FACTORY EXHAUST SYSTEM AND BACKPRESSURE SAME AS TRAP SYSTEM (47 mm FILTERS)

Test	Particulate Emission Rates						Sulfate Rates		
	Fluoropore			Fiberglass					
(Date)	g/km	g/hr	g/kg fuel	g/km	g/hr	g/kg fuel	mg/km	mg/hr	mg/kg fuel
1975 FTP									
(6/22/76)	0.288	9.075	2.738	0.300	9.441	2.832	8.320	261.62	78.4
(6/23/76)	0.311	9.787	2.888	0.304	9.562	2.835	9.216	289.56	84.1
(6/24/76)	0.279	8.769	2.618	0.281	8.852	2.656	7.785	244.60	73.9
Average	0.293	9.210	2.748	0.295	9.285	2.774	8.440	265.26	78.8
FTP$_c$									
(6/22/76)	0.303	9.552	2.495	0.327	10.295	2.686	8.909	279.91	72.5
(6/23/76)	0.382	12.000	3.110	0.364	11.401	2.959	12.606	396.06	102.6
(6/24/76)	0.310	9.755	2.524	0.304	9.578	2.479	7.851	246.65	63.9
Average	0.332	10.436	2.710	0.332	10.425	2.708	9.789	307.54	79.7
FTP$_h$									
(6/22/76)	0.278	8.716	2.921	0.280	8.797	2.942	7.876	247.82	82.9
(6/23/76)	0.258	8.118	2.721	0.260	8.174	2.742	6.658	209.22	70.1
(6/24/76)	0.256	8.026	2.689	0.264	8.305	2.789	7.736	243.05	81.4
Average	0.264	8.286	2.777	0.268	8.426	2.824	7.423	234.36	78.1
SET									
(6/22/76)	0.212	11.824	2.219	0.192	10.792	2.015	10.024	567.69	105.2
(6/23/76)	0.221	12.400	2.319	0.198	11.107	2.083	12.181	689.91	127.8
(6/24/76)	0.223	12.517	2.340	0.224	12.526	2.340	12.896	729.82	135.3
Average	0.219	12.247	2.293	0.204	11.475	21.46	11.700	662.47	122.8
FET									
(6/22/76)	0.190	14.798	2.055	0.204	15.765	2.196	7.384	572.60	79.7
(6/23/76)	0.202	15.354	2.125	0.194	15.054	2.088	10.130	785.76	109.3
(6/24/76)	0.204	15.877	2.206	0.206	15.455	2.217	11.492	891.31	124.0
Average	0.199	15.343	2.129	0.201	15.425	2.167	9.669	749.89	104.3

TABLE D-3. MERCEDES 300D PARTICULATE EMISSION RATES (8 x 10 SIZE FILTERS)

Test	Date	g/km	g/hr	g/kg fuel
Texaco A-1F, A-1R and Ethyl TAV$_s$ Traps				
1975 FTP	6/17/76	0.201	6.318	1.819
	6/18/76	0.174	5.472	1.805
	Average	0.188	5.895	1.812
FTP$_c$	6/17/76	0.249	7.833	2.120
	6/18/76	0.212	6.677	2.332
	Average	0.230	7.255	2.226
FTP$_h$	6/17/76	0.164	5.176	1.592
	6/18/76	0.145	4.563	1.407
	Average	0.154	4.870	1.499
SET-7	6/17/76	0.123	6.909	1.272
	6/18/76	0.118	6.620	1.220
	Average	0.120	6.764	1.246
FET	6/17/76	0.106	8.239	1.097
	6/18/76	0.101	7.833	1.045
	Average	0.104	8.036	1.071
Factory Stock Mufflers				
1975 FTP	6/29/76	0.289	9.110	2.463
	6/25/76	0.282	8.878	2.464
	Average	0.286	8.994	2.464
FTP$_c$	6/29/76	0.318	9.998	2.589
	6/25/76	0.313	9.843	2.697
	Average	0.316	9.920	2.643
FTP$_h$	6/21/76	0.268	8.440	2.368
	6/25/76	0.259	8.150	2.289
	Average	0.264	8.295	2.328
SET-7	6/21/76	0.206	11.585	2.575
	6/25/76	0.212	11.866	2.650
	Average	0.209	11.726	2.613
FET	6/21/76	0.179	13.894	1.929
	6/25/76	0.196	15.186	2.112
	Average	0.188	14.540	2.021

TABLE D-4. PARTICULATE EMISSION RATES OBTAINED DURING MVMA DURABILITY TEST OF TRAP SYSTEM
(Variable Fan Cooling Employed)

	Distance, km (mi)					Particulate Rate		
		Total		Test	Type			
Date	MVMA	A-1F	A-1R	Conf.	Test	g/km	g/hr	g/kg fuel
	0 (0)	2041 (1268)	2853 (1767)	These results taken to be the same as that obtained during evaluation. Refer to Tables D-1 and 2 for this data (6/15-23/76)				
9/20/76	4023 (2500)	6063 (3768)	6875 (4273)	Trap(1)	FTP$_c$	0.345	10.833	4.129(2)
					FTP$_h$	0.247	7.602	3.378(3)
						0.252	7.926	3.446(3)
						0.241	7.564	3.296(3)
				Average		0.246	7.679	3.373
10/1/76	8045	10,086	10,898	Trap(4)	FTP$_c$	0.312	9.814	3.734(2)
10/2/76	(5000)	(6268)	(6773)			0.249	7.834	2.981(2)
				Average		0.281	8.824	3.358
10/1/76					FTP$_h$	0.239	9.490	3.269(3)
10/2/76						0.218	6.851	2.981(3)
				Average		0.229	7.171	3.125
10/1/76					SET	0.227	12.711	3.328(5)
10/2/76						0.190	10.620	2.786(5)
				Average		0.209	11.666	3.057
10/1/76					FET	0.202	15.635	3.057(6)
10/2/76						0.185	14.820	2.800(6)
				Average		0.194	15.228	2.929
10/6/76	8045	10,086	10,898	Fcty(7)	FTP$_c$	0.260	8.149	3.110(2)
10/7/76	(5000)	(6268)	(6773)			0.318	9.991	3.806(2)
				Average		0.289	9.070	3.458
10/6/76					FTP$_h$	0.227	7.122	3.104(3)
10/7/76						0.273	8.558	3.734(3)
				Average		0.250	7.840	3.419
10/6/76					SET	0.187	10.435	2.742(5)
10/7/76						0.230	12.859	3.372(5)
				Average		0.209	11.647	3.057
10/6/76					FET	0.130	10.073	1.967(6)
10/7/76						0.191	14.771	2.890(6)
				Average		0.161	12.422	2.429

TABLE D-4 (Cont'd.) PARTICULATE EMISSION RATES OBTAINED DURING MVMA DURABILITY TEST OF TRAP SYSTEM
(Variable Fan Cooling Employed)

	Distance, km (mi)							
		Total		Test	Type	Particulate Rate		
Date	MVMA	A-1F	A-1R	Conf.	Test	g/km	g/hr	g/kg fuel
11/2/76	16,090	14,109	14,921	Fcty(7)	FTP$_c$	0.256	8.358	2.515
11/3/76	(10,000)	(8769)	(9273)	Fcty(8)		0.306	9.652	2.899(9)
11/2/76				Fcty(7)	FTP$_h$	0.232	7.279	2.455
11/3/76				Fcty(8)		0.270	8.456	2.858
11/2/76				Fcty(7)	SET	0.214	11.944	2.261
11/3/76				Fcty(8)		0.257	14.302	2.706
11/2/76				Fcty(7)	FET	0.206	16.054	2.460
11/3/76				Fcty(8)		0.216	16.725	2.568
11/4/76	16,090	14,109	14,921	Trap(10)	FTP$_c$	1.025	32.205	8.809
11/5/76	(10,000)	(8769)	(9273)			0.184	5.775	1.577
11/4/76					FTP$_h$	0.240	7.536	2.356
11/5/76						0.176	5.532	1.728
				Average		0.208	6.534	2.042
11/4/76					SET	0.203	11.224	2.110
11/5/76						0.194	10.806	2.042
				Average		0.199	11.015	2.076
11/4/76					FET	0.152	11.808	2.009
11/5/76						0.167	12.949	2.207
						0.159	12.379	2.108
11/18/76	16,412	14,432	15,243	Trap(11)	FTP$_c$	0.383	12.024	3.286
11/19/76	(10,200)	(8970)	(9474)			0.232	7.266	1.989
				Average		0.308	9.645	2.538
11/18/76					FTP$_h$	0.269	8.398	2.662
11/19/76						0.224	7.032	2.200
				Average		0.247	7.715	2.431
11/18/76					SET	0.204	11.376	2.142
11/19/76						0.192	10.627	2.021
				Average		0.198	11.002	2.082
11/18/76					FET	0.159	12.336	2.101
11/19/76						0.136	10.556	1.600
				Average		0.148	11.446	1.851

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(1) A-1F, A-1R, TAV$_s$. TAV$_s$ not emptied prior to test

(2) Based on 9.86 ℓ/100 km fuel consumption

(3) Based on 8.63 ℓ/100 km fuel consumption

(4) A-1F, A-1R, TAV$_s$, TAV$_s$ emptied prior to 10/1/76 FTP$_c$

TABLE D-4 (Cont'd.) PARTICULATE EMISSION RATES OBTAINED DURING MVMA DURABILITY TEST OF TRAP SYSTEM
(Variable Fan Cooling Employed)

(5) Based on 8.05 ℓ/100 km fuel consumption

(6) Based on 7.80 ℓ/100 km fuel consumption

(7) Factory mufflers installed at equivalent backpressure to trap system 381 cm Hg (150 in. H_2O) at 80.5 km/hr (50 mph)

(8) Factory mufflers at normal backpressure

(9) Based on 8.96 ℓ/100 km fuel consumption, same as 11/2/76 FTP_C

(10) After installation on car, no preconditioning, 11/4/76 FTP_C resulted in apparent removal of loose matter inside system

(11) Additional 322 km (200 miles) of MVMA service accumulation as preconditioning prior to retest

TABLE D-5. SULFATE EMISSION RATES OBTAINED AT COMPLETION OF MVMA DURABILITY TEST OF TRAP SYSTEM(10)

(Sulfate Emission Test Cycle)

	Distance, km (mi)						
		Total		Test	Sulfate Rate		
Date	MVMA	A-1F	A-1R	Conf.	mg/km	mg/hr	mg/kg fuel
11/2/76	16090	14109	14921	Fcty(2)	12.607	705.8	133.5
11/3/76	(10,000)	(8769)	(9273)	Fcty(3)	9.916	555.1	105.0
11/4/76	16090	14109	14921	Trap(4)	5.948	333.0	62.6
11/5/76	(10,000)	(8769)	(9273)		4.399	246.6	46.3
				Average	5.174	289.8	54.5
11/18/76	16412	14432	15243	Trap(5)	6.059	339.2	63.8
11/19/76	(10,200)	(8970)	(9474)		4.470	250.3	47.0
				Average	5.265	294.8	55.4

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(1) Variable fan cooling employed

(2) Factory mufflers installed at equivalent backpressure to tray system 381 cm Hg (150 in. H_2O) at 80.5 km/hr (50 mph)

(3) Factory mufflers at normal backpressure

(4) After installation on car, no preconditioning, 11/4/76 FTP_C resulted in apparent removal of loose matter inside system

(5) Additional 322 km (200 miles) of MVMA service accumulation as preconditioning prior to retest

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                              TABLE  E-2.            VEHICLE EMISSION RESULTS
                                    1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.            TEST NO. 2          DATE  7/ 2/76                 MFGR. CODE   -0                 YR. 1975
VEHICLE MODEL  MERCEDES 300D            ENGINE   3.00 LITRE 5 CYL.    TEST WT.  1587 KG               ROAD LOAD   8.4 KW
TEST TYPE  FTP-C  FTY STOCK             COMMENTS  3 BAG

BAROMETER 741.17 MM OF HG.                                          WET BULB TEMP  19.4 DEG. C
DRY BULB TEMP.   23.3 DEG. C                                         ABS. HUMIDITY  12.8 MILLIGRAMS/KG
REL. HUMIDITY     70 PCT.
EXHAUST EMISSIONS

                                                                    BLOWER INLET PRESS., G1 254.0 MM. H2O
    BLOWER DIF. PRESS., G2, 304.8 MM. H2O                           BLOWER INLET TEMP.   46 DEG. C

    BAG RESULTS
    BAG NO.                                   1             2             3
    BLOWER REVOLUTIONS                      7412         12919          7412
    HC    SAMPLE  METER READING/SCALE       14.2/2        12.9/2        16.1/2
    HC    SAMPLE  PPM                        28            26            32
    HC    BACKGRD METER READING/SCALE        2.3/2         1.2/2         7.0/2
    HC    BACKGRD PPM                        5             2             14
    CO    SAMPLE  METER READING/SCALE       16.7/*        10.2/*        16.7/*
    CO    SAMPLE  PPM                       57            34            57
    CO    BACKGRD METER READING/SCALE        .9/*          .6/*          .9/*
    CO    BACKGRD PPM                        3             2             3
    CO2   SAMPLE  METER READING/SCALE       60.0/2        34.5/2        60.0/2
    CO2   SAMPLE  PERCENT                   1.78           .97          1.78
    CO2   BACKGRD METER READING/SCALE        2.8/2         3.1/2         2.8/2
    CO2   BACKGRD PERCENT                    .07           .08           .07
    NOX   SAMPLE  METER READING/SCALE       58.7/2        35.1/2        58.7/2
    NOX   SAMPLE  PPM                       58.7          35.1          58.7
    NOX   BACKGRD METER READING/SCALE        5.4/2         4.2/2         5.4/2
    NOX   BACKGRD PPM                        5.4           4.2           5.4

    HC    CONCENTRATION PPM                   24            24            20
    CO    CONCENTRATION PPM                   51            31            51
    CO2   CONCENTRATION PCT                 1.72           .89          1.72
    NOX   CONCENTRATION PPM                 54.0          31.2          54.0
    HC    MASS GRAMS                         .77          1.29           .63
    CO    MASS GRAMS                        3.27          3.40          3.27
    CO2   MASS GRAMS                     1722.40       1561.00       1722.40
    NOX   MASS GRAMS                        6.05          6.09          6.05
     HC    MASS MG                           .77          1.29           .63

    WEIGHTED MASS HC        .16 Grams/KILOMETRE
    WEIGHTED MASS CO        .55 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    272.09 GRAMS/KILOMETRE
    WEIGHTED MASS NOX      1.01 GRAMS/KILOMETRE

   CARBON BALANCE FUEL CONSUMPTION = 10.15 LITRES PER HUNDRED KILOMETRES
   TOTAL CVS FLOW =    204.0 STD. CU. METRES
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TABLE E-3. VEHICLE EMISSION RESULTS
1975 LIGHT DUTY EMISSIONS TEST

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UNIT NO.              TEST NO. 1        DATE  7/ 6/76                 MFGR. CODE   -0               YR. 1975
VEHICLE MODEL  MERCEDES 300D FT         ENGINE   3.00 LITRE 5 CYL.    TEST WT.  3500 KG             ROAD LOAD   8.4 KW
TEST TYPE FTP-C  PART TRAPS             COMMENTS  3 BAG

BAROMETER 741.17 MM OF HG.                                            WET BULB TEMP  19.4 DEG. C
DRY BULB TEMP.    22.8 DEG. C                                          ABS. HUMIDITY  13.1 MILLIGRAMS/KG
REL. HUMIDITY      73 PCT.
EXHAUST EMISSIONS
                                                                      BLOWER INLET PRESS., G1 254.0 MM. H2O
    BLOWER DIF. PRESS., G2, 304.8 MM. H2O                             BLOWER INLET TEMP.    43 DEG. C

    BAG RESULTS
    BAG NO.                                          1              2              3
    BLOWER REVOLUTIONS                             7969          12615           7483
    HC   SAMPLE  METER READING/SCALE              8.0/2          6.2/2          9.1/2
    HC   SAMPLE  PPM                                16             12             18
    HC   BACKGRD METER READING/SCALE              3.2/2          3.7/2          3.5/2
    HC   BACKGRD PPM                                 6              7              7
    CO   SAMPLE  METER READING/SCALE             14.7/*          9.8/*         11.5/*
    CO   SAMPLE  PPM                                50             32             38
    CO   BACKGRD METER READING/SCALE              1.2/*          1.0/*           .8/*
    CO   BACKGRD PPM                                 4              4              3
    CO2  SAMPLE  METER READING/SCALE             52.9/2         32.8/2         46.3/2
    CO2  SAMPLE  PERCENT                          1.55            .92           1.33
    CO2  BACKGRD METER READING/SCALE              3.2/2          3.2/2          3.3/2
    CO2  BACKGRD PERCENT                           .08            .08            .09
    NOX  SAMPLE  METER READING/SCALE             46.8/2         29.4/2         46.4/2
    NOX  SAMPLE  PPM                              46.8           29.4           46.4
    NOX  BACKGRD METER READING/SCALE              2.5/2          2.8/2          3.0/2
    NOX  BACKGRD PPM                               2.5            2.8            3.0

    HC   CONCENTRATION PPM                          10              5             12
    CO   CONCENTRATION PPM                          44             29             34
    CO2  CONCENTRATION PCT                        1.47            .84           1.26
    NOX  CONCENTRATION PPM                        44.6           26.8           43.7
    HC   MASS GRAMS                                .35            .30            .38
    CO   MASS GRAMS                               3.02           4.08           2.22
    CO2  MASS GRAMS                            1603.41        1447.57        1289.43
    NOX  MASS GRAMS                               5.48           5.21           5.04

    WEIGHTED MASS HC        .06 GRAMS/KILOMETRE
    WEIGHTED MASS CO        .47 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    237.26 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       .86 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  8.88 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =    208.6 STD. CU. METRES
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                    TABLE  E-4.             VEHICLE EMISSION RESULTS
                           1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.              TEST NO. 2       DATE  7/ 7/76                  MFGR. CODE   -0              YR. 1975
VEHICLE MODEL  MERCEDES 300D           ENGINE   3.00 LITRE 5 CYL.     TEST WT.  3500 KG            ROAD LOAD   8.4 KW
TEST TYPE  FTP-C PART TRAPS            COMMENTS  3 BAG

BAROMETER 742.70 MM OF HG.                                          WET BULB TEMP  21.1 DEG. C
DRY BULB TEMP.   23.9 DEG. C                                         ABS. HUMIDITY  14.9 MILLIGRAMS/KG
REL. HUMIDITY     78 PCT.
EXHAUST EMISSIONS
                                                                    BLOWER INLET PRESS., G1 261.6 MM. H2O
   BLOWER DIF. PRESS., G2, 317.5 MM. H2O                            BLOWER INLET TEMP.   44 DEG. C

   BAG RESULTS
   BAG NO.                                       1              2              3
   BLOWER REVOLUTIONS                          7216          12430           7555
   HC   SAMPLE  METER READING/SCALE            31.8/1         21.8/1         14.0/1
   HC   SAMPLE  PPM                              32             22             14
   HC   BACKGRD METER READING/SCALE            19.0/1         15.2/1          6.3/1
   HC   BACKGRD PPM                              19             15              6
   CO   SAMPLE  METER READING/SCALE            18.0/*         11.3/*         12.4/*
   CO   SAMPLE  PPM                              62             38             43
   CO   BACKGRD METER READING/SCALE             3.4/*          1.8/*          1.1/*
   CO   BACKGRD PPM                              11              6              3
   CO2  SAMPLE  METER READING/SCALE            59.6/2         33.9/2         50.4/2
   CO2  SAMPLE  PERCENT                        1.77            .95           1.47
   CO2  BACKGRD METER READING/SCALE             2.4/2          2.8/2          2.4/2
   CO2  BACKGRD PERCENT                         .06            .07            .06
   NOX  SAMPLE  METER READING/SCALE            53.7/2         31.4/2         49.6/2
   NOX  SAMPLE  PPM                            53.7           31.4           49.6
   NOX  BACKGRD METER READING/SCALE             2.7/2          2.4/2          2.1/2
   NOX  BACKGRD PPM                             2.7            2.4            2.1

   HC   CONCENTRATION PPM                        15              8              8
   CO   CONCENTRATION PPM                        49             31             38
   CO2  CONCENTRATION PCT                      1.71            .88           1.41
   NOX  CONCENTRATION PPM                      51.4           29.2           47.7
   HC   MASS GRAMS                              .47            .42            .27
   CO   MASS GRAMS                             3.05           3.43           2.47
   CO2  MASS GRAMS                          1682.19        1552.20        1448.03
   NOX  MASS GRAMS                             6.08           6.19           5.91

    WEIGHTED MASS HC       .06 GRAMS/KILOMETRE
    WEIGHTED MASS CO       .51 GRAMS/KILOMETRE
    WEIGHTED MASS CO2   256.96 GRAMS/KILOMETRE
    WEIGHTED MASS NOX     1.01 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  9.60 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =   204.9 STD. CU. METRES
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                         TABLE E-5.           VEHICLE EMISSION RESULTS
                                1975  LIGHT DUTY EMISSIONS TEST
                                                                    MFGR. CODE   -U                  YR. 1975
UNIT NO.             TEST NO. 3        DATE  7/ 8/76                TEST WT.  3500 KG                ROAD LOAD   8.4 KW
VEHICLE MODEL  MERCEDES 300D  F        ENGINE   3.00 LITRE 5 CYL.
TEST TYPE FTP-C PART TRAPS             COMMENTS  3 BAG
                                                                 WET BULB TEMP  20.6 DEG. C
BAROMETER 741.43 MM OF HG.                                        ABS. HUMIDITY  14.1 MILLIGRAMS/KG
DRY BULB TEMP.    23.9 DEG. C
REL. HUMIDITY      74 PCT.
EXHAUST EMISSIONS
                                                                 BLOWER INLET PRESS., G1 254.0 MM. H2O
                                                                 BLOWER INLET TEMP.    44 DEG. C
   BLOWER DIF. PRESS., G2, 304.8 MM. H2O

   BAG RESULTS                                                2                3
   BAG NO.                                   1
   BLOWER REVOLUTIONS                      7514             12914             7522
   HC    SAMPLE  METER READING/SCALE       21.3/1            24.0/1           14.1/1
   HC    SAMPLE  PPM                        21                24               14
   HC    BACKGRD METER READING/SCALE       15.2/1            19.8/1            7.3/1
   HC    BACKGRD PPM                        15                20                7
   CO    SAMPLE  METER READING/SCALE       15.6/*            10.2/*           11.6/*
   CO    SAMPLE  PPM                        53                34               39
   CO    BACKGRD METER READING/SCALE        1.7/*             1.6/*            1.0/*
   CO    BACKGRD PPM                         5                 5                3
   CO2   SAMPLE  METER READING/SCALE       58.7/2            33.9/2           45.2/2
   CO2   SAMPLE  PERCENT                   1.74               .95             1.30
   CO2   BACKGRD METER READING/SCALE        2.4/2             2.8/2            2.6/2
   CO2   BACKGRD PERCENT                    .06               .07              .07
   NOX   SAMPLE  METER READING/SCALE       49.5/2            29.7/2           42.6/2
   NOX   SAMPLE  PPM                       49.5              29.7             42.6
   NOX   BACKGRD METER READING/SCALE        1.5/2             1.9/2            1.9/2
   NOX   BACKGRD PPM                        1.5               1.9              1.9

                                                               6                8
   HC    CONCENTRATION PPM                   8
   CO    CONCENTRATION PPM                  45                28               34
   CO2   CONCENTRATION PCT                 1.68               .88             1.24
   NOX   CONCENTRATION PPM                 48.2              27.9             40.9
   HC    MASS GRAMS                         .26               .31              .24
   CO    MASS GRAMS                        2.99              3.09             2.21
   CO2   MASS GRAMS                     1722.39           1551.90          1267.39
   NOX   MASS GRAMS                        5.78              5.75             4.90

   WEIGHTED MASS HC        .05 GRAMS/KILOMETRE
   WEIGHTED MASS CO        .47 GRAMS/KILOMETRE
   WEIGHTED MASS CO2    249.84 GRAMS/KILOMETRE
   WEIGHTED MASS NOX       .91 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  9.33 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =   207.0 STD. CU. METRES
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                              TABLE E-6.           VEHICLE EMISSION RESULTS
                                     1975  LIGHT DUTY EMISSIONS TEST
                                                                                    YR. 1975
UNIT NO. ???        TEST NO. 1        DATE  7/ 1/76                MFGR. CODE   -0         ROAD LOAD   8.4 KW
VEHICLE MODEL  MERCEDES 300D          ENGINE   3.00 LITRE 5 CYL.   TEST WT.  1587 KG
TEST TYPE  FTP-C  FTY STOCK           COMMENTS  2 BAG
                                                                   WET BULB TEMP  18.3 DEG. C
BAROMETER 740.41 MM OF HG.                                          ABS. HUMIDITY  11.1 MILLIGRAMS/KG
DRY BULB TEMP.    23.9 DEG. C
REL. HUMIDITY      59 PCT.
EXHAUST EMISSIONS
                                                                   BLOWER INLET PRESS., G1 241.3 MM. H20
                                                                   BLOWER INLET TEMP.    45 DEG. C
    BLOWER DIF. PRESS., G2, 292.1 MM. H20

    BAG RESULTS                                   1            2            3
    BAG NO.                                    7339        12907         7339
    BLOWER REVOLUTIONS                         13.0/3        8.9/3       13.0/3
    HC   SAMPLE  METER READING/SCALE             52           35           52
    HC   SAMPLE  PPM                            2.4/3        1.3/3        2.4/3
    HC   BACKGRD METER READING/SCALE             10            5           10
    HC   BACKGRD PPM                           16.5/*       10.4/*       16.5/*
    CO   SAMPLE  METER READING/SCALE             56           35           56
    CO   SAMPLE  PPM                             .7/*         .6/*         .7/*
    CO   BACKGRD METER READING/SCALE              2            2            2
    CO   BACKGRD PPM                           61.6/2       35.4/2       61.6/2
    CO2  SAMPLE  METER READING/SCALE            1.84         1.00         1.84
    CO2  SAMPLE  PERCENT                        2.7/2        3.4/2        2.7/2
    CO2  BACKGRD METER READING/SCALE             .07          .09          .07
    CO2  BACKGRD PERCENT                       59.6/2       35.3/2       59.6/2
    NOX  SAMPLE  METER READING/SCALE           59.6         35.3         59.6
    NOX  SAMPLE  PPM                            3.8/2        3.8/2        3.8/2
    NOX  BACKGRD METER READING/SCALE            3.8          3.8          3.8
    NOX  BACKGRD PPM
                                                 44           31           44
    HC   CONCENTRATION PPM                       51           31           51
    CO   CONCENTRATION PPM                      1.78          .91         1.78
    CO2  CONCENTRATION PCT                     56.3         31.8         56.3
    NOX  CONCENTRATION PPM                      1.37         1.69         1.37
    HC   MASS GRAMS                             3.26         3.50         3.26
    CO   MASS GRAMS                          1773.43      1604.95      1773.43
    CO2  MASS GRAMS                             5.93         5.89         5.93
    NOX  MASS GRAMS                             1.37         1.69         1.37
     HC   MASS MG

    WEIGHTED MASS HC        .25 Grams/KILOMETRE
    WEIGHTED MASS CO        .56 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    279.96 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       .98 GRAMS/KILOMFTRE

  CARBON BALANCE FUEL CONSUMPTION = 10.45 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =    204.2 STD. CU. METRES
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                          TABLE   E-7.            VEHICLE EMISSION RESULTS
                                 1975  LIGHT DUTY EMISSIONS TEST
UNIT NO.              TEST NO. 2            DATE  7/ 2/76                        MFGR. CODE   -0                        YR. 1975
VEHICLE MODEL  MERCEDES 300D                ENGINE   3.00 LITRE 5 CYL.           TEST WT.  1587 KG                  ROAD LOAD    8.4 KW
TEST TYPE  FTP-C  FTY STOCK                 COMMENTS  2 BAG

BAROMETER 741.17 MM OF HG.
DRY BULB TEMP.    23.3 DEG. C                                             WET BULB TEMP  19.4 DEG. C
REL. HUMIDITY      70 PCT.                                                 ABS. HUMIDITY  12.8 MILLIGRAMS/KG
EXHAUST EMISSIONS

    BLOWER DIF. PRESS., G2, 304.8 MM. H2O                                 BLOWER INLET PRESS., G1 254.0 MM. H2O
                                                                          BLOWER INLET TEMP.   46 DEG. C
    BAG RESULTS
    BAG NO.
    BLOWER REVOLUTIONS                        1              2              3
    HC    SAMPLE  METER READING/SCALE       7412          12919           7412
    HC    SAMPLE  PPM                      14.2/2          12.9/2         14.2/2
    HC    BACKGRD METER READING/SCALE        28             26              28
    HC    BACKGRD PPM                       2.3/2           1.2/2          2.3/2
    CO    SAMPLE  METER READING/SCALE         5              2               5
    CO    SAMPLE  PPM                      16.7/*          10.2/*         16.7/*
    CO    BACKGRD METER READING/SCALE        57             34              57
    CO    BACKGRD PPM                        .9/*           .6/*            .9/*
    CO2   SAMPLE  METER READING/SCALE         3              2               3
    CO2   SAMPLE  PERCENT                  60.0/2          34.5/2         60.0/2
    CO2   BACKGRD METER READING/SCALE      1.78            .97            1.78
    CO2   BACKGRD PERCENT                   2.8/2           3.1/2          2.8/2
    NOX   SAMPLE  METER READING/SCALE       .07            .08             .07
    NOX   SAMPLE  PPM                      58.7/2          35.1/2         58.7/2
    NOX   BACKGRD METER READING/SCALE      58.7            35.1           58.7
    NOX   BACKGRD PPM                       5.4/2           4.2/2          5.4/2
                                            5.4             4.2            5.4
    HC    CONCENTRATION PPM
    CO    CONCENTRATION PPM                  24             24              24
    CO2   CONCENTRATION PCT                  51             31              51
    NOX   .ONCENTRATION PPM                1.72            .89            1.72
    HC    MASS GRAMS                       54.0            31.2           54.0
    CO    MASS GRAMS                        .77            1.29            .77
    CO2   MASS GRAMS                       3.27            3.40           3.27
    NOX   MASS GRAMS                    1722.40         1561.00        1722.40
     HC    MASS MG                         6.05            6.09           6.05
                                            .77            1.29            .77

    WEIGHTED MASS HC         .17 Grams/KILOMETRE
    WEIGHTED MASS CO         .55 GRAMS/KILOMETRE
    WEIGHTED MASS CO2     272.09 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       1.01 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION = 10.15 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =    204.0 STD. CU. METRES
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                              TABLE  E-8.            VEHICLE EMISSION RESULTS
                                   1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.            TEST NO. 1           DATE  7/ 6/76                 MFGR. CODE   -0                  YR. 1975
VEHICLE MODEL  MERCEDES 300D E1          ENGINE   3.00 LITRE 5 CYL.    TEST WT. 35000 KG                ROAD LOAD   8.4 KW
TEST TYPE FTP-C PART TRAPS               COMMENTS  2 BAG .

BAROMETER 741.17 MM OF HG.                                          WET BULB TEMP  19.4 DEG. C
DRY BULB TEMP.   22.8 DEG. C                                         ABS. HUMIDITY  13.1 MILLIGRAMS/KG
REL. HUMIDITY     73 PCT.
EXHAUST EMISSIONS

                                                                    BLOWER INLET PRESS., G1 254.0 MM. H2O
   BLOWER DIF. PRESS., G2, 304.8 MM. H2O                            BLOWER INLET TEMP.    43 DEG. C

   BAG RESULTS
   BAG NO.                                         1               2               3
   BLOWER REVOLUTIONS                            2969           12615            2969
   HC   SAMPLE  METER READING/SCALE               8.0/2           6.2/2           8.0/2
   HC   SAMPLE  PPM                               16              12              16
   HC   BACKGRD METER READING/SCALE               3.2/2           3.7/2           3.2/2
   HC   BACKGRD PPM                               6               7               6
   CO   SAMPLE  METER READING/SCALE              14.7/*           9.8/*          14.7/*
   CO   SAMPLE  PPM                               50              32              50
   CO   BACKGRD METER READING/SCALE               1.2/*           1.0/*           1.2/*
   CO   BACKGRD PPM                               4               3               4
   CO2  SAMPLE  METER READING/SCALE              52.9/2          32.8/2          52.9/2
   CO2  SAMPLE  PERCENT                          1.55             .92            1.55
   CO2  BACKGRD METER READING/SCALE               3.2/2           3.2/2           3.2/2
   CO2  BACKGRD PERCENT                           .08             .08             .08
   NOX  SAMPLE  METER READING/SCALE              46.8/2          29.4/2          46.8/2
   NOX  SAMPLE  PPM                              46.8            29.4            46.8
   NOX  BACKGRD METER READING/SCALE               2.5/2           2.8/2           2.5/2
   NOX  BACKGRD PPM                               2.5             2.8             2.5

   HC   CONCENTRATION PPM                         10              5               10
   CO   CONCENTRATION PPM                         44              28              44
   CO2  CONCENTRATION PCT                        1.47             .84            1.47
   NOX  CONCENTRATION PPM                        44.6            26.8            44.6
   HC   MASS GRAMS                                .35             .30             .35
   CO   MASS GRAMS                               3.02            3.08            3.02
   CO2  MASS GRAMS                             1603.41         1447.57         1603.41
   NOX  MASS GRAMS                               5.48            5.21            5.48

   WEIGHTED MASS HC        .05 GRAMS/KILOMETRE
   WEIGHTED MASS CO        .51 GRAMS/KILOMETRE
   WEIGHTED MASS CO2   252.83 GRAMS/KILOMETRE
   WEIGHTED MASS NOX       .99 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  9.44 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =   212.2 STD. CU. METRES
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                          TABLE  E-9.          VEHICLE EMISSION RESULTS
                             1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.          TEST NO. 2         DATE  7/ 7/76                MFGR. CODE   -0              YR. 1975
VEHICLE MODEL  MERCEDES 300D         ENGINE   3.00 LITRE 5 CYL.    TEST WT. 35000 KG            ROAD LOAD    8.4 KW
TEST TYPE  FTP-C PART TRAPS          COMMENTS  2 BAG

BAROMETER 742.70 MM OF HG.                                        WET BULB TEMP  21.1 DEG. C
DRY BULB TEMP.    23.9 DEG. C                                      ABS. HUMIDITY  14.9 MILLIGRAMS/KG
REL. HUMIDITY      78 PCT.
EXHAUST EMISSIONS
                                                                  BLOWER INLET PRESS., G1 261.6 MM. H2O
   BLOWER DIF. PRESS., G2, 317.5 MM. H2O                          BLOWER INLET TEMP.    44 DEG. C

   BAG RESULTS
   BAG NO.                                  1             2             3
   BLOWER REVOLUTIONS                      7216         12930          7216
   HC    SAMPLE  METER READING/SCALE      31.0/1        21.8/1        31.0/1
   HC    SAMPLE  PPM                        31            22            31
   HC    BACKGRD METER READING/SCALE      19.0/1        15.2/1        19.0/1
   HC    BACKGRD PPM                        19            15            19
   CO    SAMPLE  METER READING/SCALE      18.0/*        11.3/*        18.0/*
   CO    SAMPLE  PPM                        62            38            62
   CO    BACKGRD METER READING/SCALE       3.4/*         1.8/*         3.4/*
   CO    BACKGRD PPM                        11             6            11
   CO2   SAMPLE  METER READING/SCALE      59.6/2        33.9/2        59.6/2
   CO2   SAMPLE  PERCENT                  1.77           .95          1.77
   CO2   BACKGRD METER READING/SCALE       2.4/2         2.8/2         2.4/2
   CO2   BACKGRD PERCENT                   .06           .07           .06
   NOX   SAMPLE  METER READING/SCALE      53.7/2        31.4/2        53.7/2
   NOX   SAMPLE  PPM                      53.7          31.4          53.7
   NOX   BACKGRD METER READING/SCALE       2.7/2         2.4/2         2.7/2
   NOX   BACKGRD PPM                       2.7           2.4           2.7

   HC    CONCENTRATION PPM                  15             8            15
   CO    CONCENTRATION PPM                  49            31            49
   CO2   CONCENTRATION PCT                1.71           .88          1.71
   NOX   CONCENTRATION PPM                51.4          29.2          51.4
   HC    MASS GRAMS                        .45           .42           .45
   CO    MASS GRAMS                       3.05          3.43          3.05
   CO2   MASS GRAMS                    1682.19       1552.20       1682.19
   NOX   MASS GRAMS                       6.09          6.19          6.08

   WEIGHTED MASS HC       .07 GRAMS/KILOMETRE
   WEIGHTED MASS CO       .54 GRAMS/KILOMETRE
   WEIGHTED MASS CO2   268.03 GRAMS/KILOMETRE
   WEIGHTED MASS NOX     1.02 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION = 10.01 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =    202.4 STD. CU. METRES
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                                   TABLE  E-10.               VEHICLE EMISSION RESULTS
                                     1975  LIGHT DUTY EMISSIONS TEST
                                                                                                YR. 1975
                                               DATE  7/ 8/76                MFGR. CODE   -0     ROAD LOAD   8.4 KW
UNIT NO. 111         TEST NO. 3                ENGINE   3.00 LITRE 5 CYL.    TEST WT.  3500 KG
VEHICLE MODEL  MERCEDES 300D  F                COMMENTS  2 BAG
TEST TYPE FTP-C PART TRAPS
                                                                            WET BULB TEMP  20.6 DEG. C
BAROMETER 741.43 MM OF HG.                                                   ABS. HUMIDITY  14.1 MILLIGRAMS/KG
DRY BULB TEMP.   23.9 DEG. C
REL. HUMIDITY     74 PCT.
EXHAUST EMISSIONS
                                                                            BLOWER INLET PRESS., G1 254.0 MM. H2O
                                                                            BLOWER INLET TEMP.    44 DEG. C
    BLOWER DIF. PRESS., G2, 304.8 MM. H2O

    BAG RESULTS
    BAG NO.                                            1              2              3
    BLOWER REVOLUTIONS                                7514          12914           7514
    HC   SAMPLE  METER READING/SCALE                21.3/1         24.0/1         21.3/1
    HC   SAMPLE  PPM                                  21             24             21
    HC   BACKGRD METER READING/SCALE                15.2/1         19.8/1         15.2/1
    HC   BACKGRD PPM                                  15             20             15
    CO   SAMPLE  METER READING/SCALE                15.6/*         10.2/*         15.6/*
    CO   SAMPLE  PPM                                  53             34             53
    CO   BACKGRD METER READING/SCALE                 1.7/*          1.6/*          1.7/*
    CO   BACKGRD PPM                                   5              5              5
    CO2  SAMPLE  METER READING/SCALE                58.7/2         33.9/2         58.7/2
    CO2  SAMPLE  PERCENT                            1.74            .95           1.74
    CO2  BACKGRD METER READING/SCALE                 2.4/2          2.8/2          2.4/2
    CO2  BACKGRD PERCENT                             .06            .07            .06
    NOX  SAMPLE  METER READING/SCALE                49.5/2         29.7/2         49.5/2
    NOX  SAMPLE  PPM                                49.5           29.7           49.5
    NOX  BACKGRD METER READING/SCALE                 1.5/2          1.9/2          1.5/2
    NOX  BACKGRD PPM                                 1.5            1.9            1.5
                                                       8              6              8
    HC   CONCENTRATION PPM                            45             28             45
    CO   CONCENTRATION PPM                          1.68            .88           1.69
    CO2  CONCENTRATION PCT                          48.2           27.9           48.2
    NOX  CONCENTRATION PPM                           .26            .31            .26
    HC   MASS GRAMS                                 2.94           3.09           2.94
    CO   MASS GRAMS                              1722.39        1551.90        1722.39
    CO2  MASS GRAMS                                 5.78           5.75           5.78
    NOX  MASS GRAMS

     WEIGHTED MASS HC        .05 GRAMS/KILOMETRE
     WEIGHTED MASS CO        .50 GRAMS/KILOMETRE
     WEIGHTED MASS CO2    271.33 GRAMS/KILOMETRE
     WEIGHTED MASS NOX       .96 GRAMS/KILOMETRE

    CARBON BALANCE FUEL CONSUMPTION = 10.13 LITRES PER HUNDRED KILOMETRES
    TOTAL CVS FLOW =    206.9 STD. CU. METRES
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                        TABLE E-11.          VEHICLE EMISSION RESULTS
                            1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.             TEST NO. 1          DATE  7/ 1/76                  MFGR. CODE   -0                 YR. 1975
VEHICLE MODEL  MERCEDES 300D             ENGINE   3.00 LITRE 5 CYL.     TEST WT.  1587 KG               ROAD LOAD    8.4 KW
TEST TYPE  FTP-H FTY STOCK               COMMENTS  2 BAG

BAROMETER 740.41 MM OF HG.                                            WET BULB TEMP  20.0 DEG. C
DRY BULB TEMP.   25.6 DEG. C                                           ABS. HUMIDITY  12.6 MILLIGRAMS/KG
REL. HUMIDITY     60 PCT.
EXHAUST EMISSIONS

                                                                      BLOWER INLET PRESS., G1 254.0 MM. H2O
   BLOWER DIF. PRESS., G2, 317.5 MM. H2O                              BLOWER INLET TEMP.   45 DEG. C

   BAG RESULTS
   BAG NO.                                       1            2            3
   BLOWER REVOLUTIONS                          7518        12905         7518
   HC   SAMPLE  METER READING/SCALE            13.4/2       12.7/2       13.4/2
   HC   SAMPLE  PPM                              27           25           27
   HC   BACKGRD METER READING/SCALE             3.9/2        3.0/2        3.9/2
   HC   BACKGRD PPM                               8            6            8
   CO   SAMPLE  METER READING/SCALE            12.9/*        9.7/*       12.9/*
   CO   SAMPLE  PPM                              43           32           43
   CO   BACKGRD METER READING/SCALE              .3/*        0.0/*         .3/*
   CO   BACKGRD PPM                               1            0            1
   CO2  SAMPLE  METER READING/SCALE            50.1/2       33.5/2       50.1/2
   CO2  SAMPLE  PERCENT                        1.46          .94         1.46
   CO2  BACKGRD METER READING/SCALE             2.2/2        2.5/2        2.2/2
   CO2  BACKGRD PERCENT                         .06          .07          .06
   NOX  SAMPLE  METER READING/SCALE            52.8/2       35.2/2       52.8/2
   NOX  SAMPLE  PPM                            52.8         35.2         52.8
   NOX  BACKGRD METER READING/SCALE             3.0/2        3.6/2        3.0/2
   NOX  BACKGRD PPM                             3.0          3.6          3.0

   HC   CONCENTRATION PPM                        20           20           20
   CO   CONCENTRATION PPM                        40           31           40
   CO2  CONCENTRATION PCT                      1.40          .88         1.40
   NOX  CONCENTRATION PPM                      50.1         31.9         50.1
   HC   MASS GRAMS                              .64         1.09          .64
   CO   MASS GRAMS                             2.61         3.42         2.61
   CO2  MASS GRAMS                          1429.14      1533.79      1429.14
   NOX  MASS GRAMS                             5.66         6.18         5.66
    HC   MASS MG                                .64         1.09          .64

   WEIGHTED MASS HC        .14 Grams/KILOMETRE
   WEIGHTED MASS CO        .50 GRAMS/KILOMETRE
   WEIGHTED MASS CO2    245.53 GRAMS/KILOMETRE
   WEIGHTED MASS NOX       .98 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  9.16 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =   205.7 STD. CU. METRES
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                  TABLE E-12.            VEHICLE EMISSION RESULTS
                             1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.            TEST NO. 2          DATE  7/ 2/76               MFGR. CODE   -0              YR. 1975
VEHICLE MODEL  MERCEDES 300D            ENGINE   3.00 LITRE 5 CYL.  TEST WT.  1587 KG            ROAD LOAD    8.4 KW
TEST TYPE  FTP-H  FTY STOCK             COMMENTS  2 BAG

BAROMETER 740.92 MM OF HG.                                   WET BULB TEMP  18.9 DEG. C
DRY BULB TEMP.    23.9 DEG. C                                 ABS. HUMIDITY  11.8 MILLIGRAMS/KG
REL. HUMIDITY     62 PCT.
EXHAUST EMISSIONS
                                                             BLOWER INLET PRESS., G1 254.0 MM. H2O
   BLOWER DIF. PRESS., G2, 304.8 MM. H2O                     BLOWER INLET TEMP.    37 DEG. C

   BAG RESULTS
   BAG NO.                                     1             2             3
   BLOWER REVOLUTIONS                       7532         12933          7412
   HC   SAMPLE  METER READING/SCALE       15.8/2        14.2/2        16.1/2
   HC   SAMPLE  PPM                         32            28            32
   HC   BACKGRD METER READING/SCALE        7.0/2         5.2/2         7.0/2
   HC   BACKGRD PPM                         14            10            14
   CO   SAMPLE  METER READING/SCALE       13.1/*        10.0/*        16.7/*
   CO   SAMPLE  PPM                         44            33            57
   CO   BACKGRD METER READING/SCALE         .3/*          .4/*          .9/*
   CO   BACKGRD PPM                          1             1             3
   CO2  SAMPLE  METER READING/SCALE       49.6/2        33.8/2        60.0/2
   CO2  SAMPLE  PERCENT                   1.44           .95          1.78
   CO2  BACKGRD METER READING/SCALE        2.6/2         3.9/2         2.8/2
   CO2  BACKGRD PERCENT                    .07           .10           .07
   NOX  SAMPLE  METER READING/SCALE       54.5/2        34.8/2        58.7/2
   NOX  SAMPLE  PPM                       54.5          34.8          58.7
   NOX  BACKGRD METER READING/SCALE        3.7/2         3.7/2         5.4/2
   NOX  BACKGRD PPM                        3.7           3.7           5.4

   HC   CONCENTRATION PPM                   19            19            20
   CO   CONCENTRATION PPM                   41            31            52
   CO2  CONCENTRATION PCT                 1.38           .85          1.72
   NOX  CONCENTRATION PPM                 51.2          31.4          54.0
   HC   MASS GRAMS                         .63          1.06           .65
   CO   MASS GRAMS                        2.74          3.51          3.38
   CO2  MASS GRAMS                     1449.05       1538.58       1777.07
   NOX  MASS GRAMS                        5.81          6.12          6.04
    HC   MASS MG                           .63          1.06           .65

   WEIGHTED MASS HC        .14 Grams/KILOMETRE
   WEIGHTED MASS CO        .55 GRAMS/KILOMETRE
   WEIGHTED MASS CO2    263.07 GRAMS/KILOMETRE
   WEIGHTED MASS NOX      1.00 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  9.82 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =    211.6 STD. CU. METRES
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                         TABLE E-13.           VEHICLE EMISSION RESULTS
                              1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.             TEST NO. 1          DATE  7/ 6/76                    MFGR. CODE   -0                 YR. 1975
VEHICLE MODEL  MERCEDES 300D FT          ENGINE   3.00 LITRE 5 CYL.       TEST WT.  3500 KG               ROAD LOAD   8.4 kW
TEST TYPE FTP-H PART TRAPS               COMMENTS  2 BAG

BAROMETER 741.17 MM OF HG.                                               WET BULB TEMP  20.0 DEG. C
DRY BULB TEMP.    24.4 DEG. C                                             ABS. HUMIDITY  13.1 MILLIGRAMS/KG
REL. HUMIDITY      67 PCT.
EXHAUST EMISSIONS

                                                                         BLOWER INLET PRESS., G1 254.0 MM. H2O
     BLOWER DIF. PRESS., G2, 304.8 MM. H2O                               BLOWER INLET TEMP.    43 DEG. C

     BAG RESULTS
     BAG NO.                                             1               2               3
     BLOWER REVOLUTIONS                                7483           12545            7483
     HC    SAMPLE  METER READING/SCALE                9.1/2           4.9/2           9.1/2
     HC    SAMPLE  PPM                                  18              10              18
     HC    BACKGRD METER READING/SCALE                3.5/2           1.7/2           3.5/2
     HC    BACKGRD PPM                                   7               3               7
     CO    SAMPLE  METER READING/SCALE               11.5/*           9.2/*          11.5/*
     CO    SAMPLE  PPM                                  38              30              38
     CO    BACKGRD METER READING/SCALE                 .8/*            .9/*            .8/*
     CO    BACKGRD PPM                                   3               3               3
     CO2   SAMPLE  METER READING/SCALE               46.3/2          31.2/2          46.3/2
     CO2   SAMPLE  PERCENT                            1.33             .87            1.33
     CO2   BACKGRD METER READING/SCALE                3.3/2           3.4/2           3.3/2
     CO2   BACKGRD PERCENT                             .09             .09             .09
     NOX   SAMPLE  METER READING/SCALE               46.4/2          29.5/2          46.4/2
     NOX   SAMPLE  PPM                                46.4            24.5            46.4
     NOX   BACKGRD METER READING/SCALE                3.0/2           3.1/2           3.0/2
     NOX   BACKGRD PPM                                 3.0             3.1             3.0

     HC    CONCENTRATION PPM                            12               7              12
     CO    CONCENTRATION PPM                            34              27              34
     CO2   CONCENTRATION PCT                          1.26             .79            1.26
     NOX   CONCENTRATION PPM                          43.7            26.6            43.7
     HC    MASS GRAMS                                  .38             .35             .38
     CO    MASS GRAMS                                 2.22            2.89            2.22
     CO2   MASS GRAMS                              1284.43         1348.77         1284.43
     NOX   MASS GRAMS                                 5.05            5.15            5.05

     WEIGHTED MASS HC        .06 GRAMS/KILOMETRE
     WEIGHTED MASS CO        .42 GRAMS/KILOMETRE
     WEIGHTED MASS CO2    218.21 GRAMS/KILOMETRE
     WEIGHTED MASS NOX       .84 GRAMS/KILOMETRE

   CARBON BALANCE FUEL CONSUMPTION =  8.15 LITRES PER HUNDRED KILOMETRES
   TOTAL CVS FLOW =    204.5 STD. CU. METRES
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                          TABLE  E-14.           VEHICLE EMISSION RESULTS
                                 1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.             TEST NO. 2            DATE  7/ 7/76                 MFGR. CODE   -0                YR. 1975
VEHICLE MODEL  MERCEDES 300-D              ENGINE   3.00 LITRE 5 CYL.    TEST WT.  3500 KG              ROAD LOAD   8.4 KW
TEST TYPE  FTP-H PART TRAPS                COMMENTS  2 BAG

BAROMETER 742.70 MM OF HG.                                               WET BULB TEMP  21.1 DEG. C
DRY BULB TEMP.    24.4 DEG. C                                             ABS. HUMIDITY  14.6 MILLIGRAMS/KG
REL. HUMIDITY      74 PCT.
EXHAUST EMISSIONS

                                                                         BLOWER INLET PRESS., G1 254.0 MM. H2O
    BLOWER DIF. PRESS., G2, 312.4 MM. H2O                                BLOWER INLET TEMP.    43 DEG. C

    BAG RESULTS
    BAG NO.                                       1            2            3
    BLOWER REVOLUTIONS                          7555        12916         7555
    HC    SAMPLE  METER READING/SCALE          13.0/1       17.1/1       13.0/1
    HC    SAMPLE  PPM                            13           17           13
    HC    BACKGRD METER READING/SCALE           6.3/1       12.7/1        6.3/1
    HC    BACKGRD PPM                             6           13            6
    CO    SAMPLE  METER READING/SCALE          12.9/*       10.5/*       12.9/*
    CO    SAMPLE  PPM                            43           35           43
    CO    BACKGRD METER READING/SCALE           1.1/*        1.1/*        1.1/*
    CO    BACKGRD PPM                             3            3            3
    CO2   SAMPLE  METER READING/SCALE          50.4/2       33.8/2       50.4/2
    CO2   SAMPLE  PERCENT                      1.47          .95         1.47
    CO2   BACKGRD METER READING/SCALE           2.4/2        3.2/2        2.4/2
    CO2   BACKGRD PERCENT                       .06          .08          .06
    NOX   SAMPLE  METER READING/SCALE          49.6/2       31.7/2       49.6/2
    NOX   SAMPLE  PPM                          49.6         31.7         49.6
    NOX   BACKGRD METER READING/SCALE           2.1/2        2.5/2        2.1/2
    NOX   BACKGRD PPM                           2.1          2.5          2.1

    HC    CONCENTRATION PPM                       7            5            7
    CO    CONCENTRATION PPM                      38           40           38
    CO2   CONCENTRATION PCT                    1.41          .87         1.41
    NOX   CONCENTRATION PPM                    47.7         29.4         47.7
    HC    MASS GRAMS                            .24          .30          .24
    CO    MASS GRAMS                           2.49         3.38         2.49
    CO2   MASS GRAMS                        1456.54      1536.93      1456.54
    NOX   MASS GRAMS                           5.89         6.20         5.89

    WEIGHTED MASS HC        .04 GRAMS/KILOMETRE
    WEIGHTED MASS CO        .49 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    248.06 GRAMS/KILOMETRE
    WEIGHTED MASS NOX      1.00 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  9.26 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =   208.5 STD. CU. METRES
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TABLE E-15.               VEHICLE EMISSION RESULTS
               1975  LIGHT DUTY EMISSIONS TEST

                                                          MFGR. CODE   -0                  YR. 1975
UNIT NO.  ###        TEST NO. 3      DATE  7/ 8/76         TEST WT.   3500 KG              ROAD LOAD    8.4 KW
VEHICLE MODEL  MERCEDES 300D  F      ENGINE   3.00 LITRE 5 CYL.
TEST TYPE FTP-H PART TRAPS           COMMENTS  2 BAG
                                                          WET BULB TEMP  20.6 DEG. C
BAROMETER 741.43 MM OF HG.                                 ABS. HUMIDITY  13.6 MILLIGRAMS/KG
DRY BULB TEMP.    25.0 DEG. C
REL. HUMIDITY      67 PCT.
EXHAUST EMISSIONS
                                                          BLOWER INLET PRESS., G1 254.0 MM. H2O
                                                          BLOWER INLET TEMP.    44 DEG. C
    BLOWER DIF. PRESS., G2, 304.8 MM. H2O

    BAG RESULTS
    BAG NO.                                     1            2             3
    BLOWER REVOLUTIONS                       7522        12906          7522
    HC   SAMPLE  METER READING/SCALE         14.1/1       24.1/1        14.1/1
    HC   SAMPLE  PPM                          14           24            14
    HC   BACKGRD METER READING/SCALE          7.3/1       16.9/1         7.3/1
    HC   BACKGRD PPM                          7            17             7
    CO   SAMPLE  METER READING/SCALE         11.6/*        9.7/*        11.6/*
    CO   SAMPLE  PPM                          39           32            39
    CO   BACKGRD METER READING/SCALE          1.0/*        .9/*          1.0/*
    CO   BACKGRD PPM                          3            3             3
    CO2  SAMPLE  METER READING/SCALE         45.2/2       32.0/2        45.2/2
    CO2  SAMPLE  PERCENT                     1.30          .89          1.30
    CO2  BACKGRD METER READING/SCALE          2.6/2        2.2/2         2.6/2
    CO2  BACKGRD PERCENT                      .07          .06           .07
    NOX  SAMPLE  METER READING/SCALE         42.6/2       29.4/2        42.6/2
    NOX  SAMPLE  PPM                         42.6         29.4          42.6
    NOX  BACKGRD METER READING/SCALE          1.9/2        2.2/2         1.9/2
    NOX  BACKGRD PPM                          1.9          2.2           1.9

    HC   CONCENTRATION PPM                     8            8             8
    CO   CONCENTRATION PPM                    34           29            34
    CO2  CONCENTRATION PCT                   1.24          .84          1.24
    NOX  CONCENTRATION PPM                   40.9         27.3          40.9
    HC   MASS GRAMS                           .24          .46           .24
    CO   MASS GRAMS                          2.21         3.14          2.21
    CO2  MASS GRAMS                       1267.39      1476.34       1267.39
    NOX  MASS GRAMS                          4.82         5.53          4.92

    WEIGHTED MASS HC       .06 GRAMS/KILOMETRE
    WEIGHTED MASS CO       .44 GRAMS/KILOMETRE
    WEIGHTED MASS CO2   227.37 GRAMS/KILOMETRE
    WEIGHTED MASS NOX      .86 GRAMS/KILOMETRE

   CARBON BALANCE FUEL CONSUMPTION =  8.49 LITRES PER HUNDRED KILOMETRES
   TOTAL CVS FLOW =    206.9 STD. CU. METRES
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        TABLE E-16.  EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
                            VEHICLE NUMBER

                               TIME     -0 HRS.         TEST NO.  1
DATE  7/ 1/76                  SET-7 FTY STOCK          ENGINE 3.0 LITRE I  5 CYL.
MODEL  1975 MERCEDES-300D      TEST WT.  1587 KG.       GVW    0 KG
DRIVER   DT                    DRY BULB TEMP  26 C      REL. HUM.  53.1 PCT
WET BULB TEMP  19 C            BARO.  740.4 MM  HG.     MEASURED FUEL  0.00 KG
SPEC. HUM.  11.1 GRAM/KG       FUEL 847.3 G/LITRE     FUEL HC  RATIO 1.844
DISTANCE  21.738 KM

  RUN DURATION            23.33 MINUTES
  BLOWER INLET PRESS. 248.9  MM. H2O
  BLOWER DIF.  PRESS. 294.6  MM  H2O
  BLOWER INLET TEMP.      46  DEG. C
  DYNO REVOLUTIONS     31747
  BLOWER REVOLUTIONS    20818
  BLOWER CU. CM /REV.  8438

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE                12.8/2
   HC   SAMPLE  PPM                                  26
   HC   BACKGRD METER READING/SCALE                 1.0/2
   HC   BACKGRD PPM                                   2
   CO   SAMPLE  METER READING/SCALE                14.6/*
   CO   SAMPLE  PPM                                  49
   CO   BACKGRD METER READING/SCALE                 .4/*
   CO   BACKGRD PPM                                   1
   CO2  SAMPLE  METER READING/SCALE                58.4/2
   CO2  SAMPLE  PERCENT                             1.73
   CO2  BACKGRD METER READING/SCALE                 2.9/2
   CO2  BACKGRD PERCENT                             .08
   NOX  SAMPLE  METER READING/SCALE                66.1/2
   NOX  SAMPLE  PPM                                66.1
   NOX  BACKGRD METER READING/SCALE                 3.3/2
   NOX  BACKGRD PPM                                 3.3
   HC   CONCENTRATION PPM                            24
   CO   CONCENTRATION PPM                            46
   CO2  CONCENTRATION PCT                          1.66
   NOX  CONCENTRATION PPM                          63.2
   SO2  COCENTRATION PPM                            0.0
   HC   MASS (GRAMS)                               2.11
   CO   MASS (GRAMS)                               8.19
   CO2  MASS (GRAMS)                            4684.34
   NOX  MASS (GRAMS)                              18.79
   SO2  MASS (GRAMS)                               0.00

 HC   GRAMS/KILOMETRE      .10
 CO   GRAMS/KILOMETRE      .38
 CO2  GRAMS/KILOMETRE    215
 NOX  GRAMS/KILOMETRE      .86
 SO2  GRAMS/KILOMETRE     0.00

 HC   GRAMS/KG OF FUEL   1.42     HC   GRAMS/MIN       .1
 CO   GRAMS/KG OF FUEL    5.5     CO   GRAMS/MIN      .4
 CO2  GRAMS/KG OF FUEL   3160     CO2  GRAMS/MIN    201
 NOX  GRAMS/KG OF FUEL  12.67     NOX  GRAMS/MIN     .81
 SO2  GRAMS/KG OF FUEL   0.00     SO2  GRAMS/MIN    0.00

 CARBON BALANCE FUEL CONSUMPTION =  8.05 LITRES PER HUNDRED KILOMETRES
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TABLE E-17. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

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                                                          TEST NO.  2
DATE  7/ 2/76                    TIME     -0 HRS.          ENGINE 3.0 LITRE I  5 CYL.
MODEL  1975 MERCEDES 300-D SET-7 FTY STOCK                GVW    0 KG
DRIVER   BY                      TEST WT.  1587 KG.        REL. HUM.  49.1 PCT
WET BULB TEMP  18 C              DRY BULH TEMP  25 C       MEASURED FUEL  0.00 KG
SPEC. HUM.    9.9 GRAM/KG        BARO.  741.2 MM  HG.    FUEL HC  RATIO 1.844
DISTANCE  21.738 KM              FUEL 847.3 G/LITRE

  RUN DURATION           23.29 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H20
  BLOWER DIF.  PRESS. 304.8  MM  H20
  BLOWER INLET TEMP.     43  DEG. C
  DYNO REVOLUTIONS    31609
  BLOWER REVOLUTIONS    20774
  BLOWER CU. CM /REV.  8440

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE                 15.5/2
   HC   SAMPLE  PPM                                   31
   HC   BACKGRD METER READING/SCALE                  8.9/2
   HC   BACKGRD PPM                                   18
   CO   SAMPLE  METER READING/SCALE                 15.5/*
   CO   SAMPLE  PPM                                   53
   CO   BACKGRD METER READING/SCALE                   .6/*
   CO   BACKGRD PPM                                    2
   CO2  SAMPLE  METER READING/SCALE                 57.5/2
   CO2  SAMPLE  PERCENT                              1.70
   CO2  BACKGRD METER READING/SCALE                  3.1/2
   CO2  BACKGRD PERCENT                               .08
   NOX  SAMPLE  METER READING/SCALE                 68.3/2
   NOX  SAMPLE  PPM                                 68.3
   NOX  BACKGRD METER READING/SCALE                  4.4/2
   NOX  BACKGRD PPM                                  4.4
   HC   CONCENTRATION PPM                             15
   CO   CONCENTRATION PPM                             49
   CO2  CONCENTRATION PCT                           1.63
   NOX  CONCENTRATION PPM                           64.5
   SO2  COCENIRATION PPM                             0.0
   HC   MASS (GRAMS)                                1.38
   CO   MASS (GRAMS)                                8.73
   CO2  MASS (GRAMS)                             4619.89
   NOX  MASS (GRAMS)                               18.55
   SO2  MASS (GRAMS)                                0.00

HC   GRAMS/KILOMETRE       .06
CO   GRAMS/KILOMETRE       .40
CO2  GRAMS/KILOMETRE   213
NOX  GRAMS/KILOMETRE       .85
SO2  GRAMS/KILOMETRE      0.00

HC   GRAMS/KG OF FUEL    .94     HC   GRAMS/MIN        .1
CO   GRAMS/KG OF FUEL    6.0     CO   GRAMS/MIN       .4
CO2  GRAMS/KG OF FUEL   3161     CO2  GRAMS/MIN     198
NOX  GRAMS/KG OF FUEL  12.69     NOX  GRAMS/MIN     .80
SO2  GRAMS/KG OF FUEL   0.00     SO2  GRAMS/MIN    0.00

CARBON BALANCE FUEL CONSUMPTION =  7.94 LITRES PER HUNDRED KILOMETRES
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TABLE E-18. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

```
DATE  7/ 6/76                TIME    -0 HRS.         TEST NO.  1
MODEL  1972 MERCEDES 300D    SET7 PART TRAPS         ENGINE 3.0 LITRE I  5 CYL.
DRIVER   DT                  TEST WT.  1587 KG.      GVW    0 KG
WET BULB TEMP  20 C          DRY BULB TEMP  24 C     REL. HUM.  70.1 PCT
SPEC. HUM.  13.3 GRAM/KG     BARO.  741.2 MM  HG.    MEASURED FUEL  0.00 KG
DISTANCE  21.738 KM          FUEL 847.3 G/LITRE   FUEL HC  RATIO 1.844

  RUN DURATION           23.01 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 304.8  MM  H2O
  BLOWER INLET TEMP.     45  DEG. C
  DYNO REVOLUTIONS    31117
  BLOWER REVOLUTIONS    20521
  BLOWER CU. CM /REV.  8430

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE              8.8/2
   HC   SAMPLE  PPM                               18
   HC   BACKGRD METER READING/SCALE              2.5/2
   HC   BACKGRD PPM                                5
   CO   SAMPLE  METER READING/SCALE             14.1/*
   CO   SAMPLE  PPM                               48
   CO   BACKGRD METER READING/SCALE               .7/*
   CO   BACKGRD PPM                                2
   CO2 SAMPLE  METER READING/SCALE              54.8/2
   CO2 SAMPLE  PERCENT                          1.61
   CO2 BACKGRD METER READING/SCALE               2.0/2
   CO2 BACKGRD PERCENT                           .05
   NOX SAMPLE  METER READING/SCALE              59.0/2
   NOX SAMPLE  PPM                              59.0
   NOX BACKGRD METER READING/SLALE               3.4/2
   NOX BACKGRD PPM                               3.4
   HC  CONCENTRATION PPM                          13
   CO  CONCENTRATION PPM                          43
   CO2 CONCENTRATION PCT                        1.56
   NOX CONCENTRATION PPM                        56.0
   SO2 COCENTRATION PPM                          0.0
   HC  MASS (GRAMS)                             1.16
   CO  MASS (GRAMS)                             7.62
   CO2 MASS (GRAMS)                          4355.06
   NOX MASS (GRAMS)                            17.77
   SO2 MASS (GRAMS)                             0.00

HC   GRAMS/KILOMETRE       .05
CO   GRAMS/KILOMETRE       .35
CO2 GRAMS/KILOMETRE   200
NOX GRAMS/KILOMETRE        .82
SO2 GRAMS/KILOMETRE      0.00

HC   GRAMS/KG OF FUEL    .84     HC   GRAMS/MIN        .1
CO   GRAMS/KG OF FUEL    5.5     CO   GRAMS/MIN       .3
CO2 GRAMS/KG OF FUEL   3162     CO2 GRAMS/MIN     189
NOX GRAMS/KG OF FUEL  12.90     NOX GRAMS/MIN     .77
SO2 GRAMS/KG OF FUEL   0.00     SO2 GRAMS/MIN    0.00

CARBON BALANCE FUEL CONSUMPTION =  7.48 LITRES PER HUNDRED KILOMETRES
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        TABLE E-19.  EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
                             VEHICLE NUMBER

DATE  7/ 7/76                TIME     -0 HRS.           TEST NO.  2
MODEL  1975 MERCEDES-300D    SET7 PART TRAPS            ENGINE 3.0 LITRE I  5 CYL.
DRIVER   DT                  TEST WT.  1587 KG.         GVW    0 KG
WET BULB TEMP  21 C          DRY BULB TEMP  25 C        REL. HUM.  67.0 PCT
SPEC. HUM.  13.6 GRAM/KG     BARO.  742.7 MM  HG.       MEASURED FUEL  0.00 KG
DISTANCE  21.738 KM          FUEL 847.3 G/LITRE    FUEL HC  RATIO 1.844

  RUN DURATION          23.30 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H20
  BLOWER DIF.  PRESS. 304.8  MM  H20
  BLOWER INLET TEMP.      46  DEG. C
  DYNO REVOLUTIONS    31861
  BLOWER REVOLUTIONS    20786
  BLOWER CU. CM /REV.  8425

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE             11.5/1
   HC   SAMPLE  PPM                               11
   HC   BACKGRD METER READING/SCALE              5.0/1
   HC   BACKGRD PPM                                5
   CO   SAMPLE  METER READING/SCALE             14.9/*
   CO   SAMPLE  PPM                               51
   CO   BACKGRD METER READING/SCALE              1.2/*
   CO   BACKGRD PPM                                4
   CO2  SAMPLE  METER READING/SCALE             62.7/2
   CO2  SAMPLE  PERCENT                         1.87
   CO2  BACKGRD METER READING/SCALE              2.5/2
   CO2  BACKGRD PERCENT                          .07
   NOX  SAMPLE  METER READING/SCALE             70.6/2
   NOX  SAMPLE  PPM                             70.6
   NOX  BACKGRD METER READING/SCALE              3.6/2
   NOX  BACKGRD PPM                              3.6
   HC   CONCENTRATION PPM                          7
   CO   CONCENTRATION PPM                         44
   CO2  CONCENTRATION PCT                       1.82
   NOX  CONCENTRATION PPM                       67.5
   SO2  COCENTRATION PPM                        0.0
   HC   MASS (GRAMS)                             .64
   CO   MASS (GRAMS)                            7.92
   CO2  MASS (GRAMS)                         5119.64
   NOX  MASS (GRAMS)                           21.85
   SO2  MASS (GRAMS)                            0.00

HC   GRAMS/KILOMETRE       .03
CO   GRAMS/KILOMETRE       .36
CO2  GRAMS/KILOMETRE   236
NOX  GRAMS/KILOMETRE      1.01
SO2  GRAMS/KILOMETRE      0.00

HC   GRAMS/KG OF FUEL     .39     HC   GRAMS/MIN        .0
CO   GRAMS/KG OF FUEL     4.9     CO   GRAMS/MIN       .3
CO2  GRAMS/KG OF FUEL    3164     CO2  GRAMS/MIN     220
NOX  GRAMS/KG OF FUEL   13.51     NOX  GRAMS/MIN      .94
SO2  GRAMS/KG OF FUEL    0.00     SO2  GRAMS/MIN    0.00

CARBON BALANCE FUEL CONSUMPTION -  8.39 LITRES PER HUNDRED KILOMETRES
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TABLE E-20. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

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DATE  7/ 8/76                 TIME    -0 HRS.           TEST NO.  3
MODEL  1975 MERCEDES 300D     SET7 PART TRAPS           ENGINE 3.0 LITRE I  5 CYL.
DRIVER   DT                   TEST WT.  1587 KG.        GVW    0 KG
WET BULB TEMP  18 C           DRY BULB TEMP  24 C       REL. HUM.  55.5 PCT
SPEC. HUM.  10.9 GRAM/KG      BARO.  741.4 MM  HG.      MEASURED FUEL  0.00 KG
DISTANCE  21.738 KM           FUEL 847.3 G/LITRE    FUEL HC  RATIO 1.844

  RUN DURATION           22.94 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 304.8  MM  H2O
  BLOWER INLET TEMP.     45  DEG. C
  DYNO REVOLUTIONS    31196
  BLOWER REVOLUTIONS    20462
  BLOWER CU. CM /REV.  8431

  BAG RESULTS
   HC  SAMPLE  METER READING/SCALE           12.2/1
   HC  SAMPLE  PPM                            12
   HC  BACKGRD METER READING/SCALE            2.4/1
   HC  BACKGRD PPM                            2
   CO  SAMPLE  METER READING/SCALE           13.7/*
   CO  SAMPLE  PPM                            46
   CO  BACKGRD METER READING/SCALE             .9/*
   CO  BACKGRD PPM                            3
   CO2 SAMPLE  METER READING/SCALE           57.9/2
   CO2 SAMPLE  PERCENT                       1.71
   CO2 BACKGRD METER READING/SCALE            2.5/2
   CO2 BACKGRD PERCENT                        .07
   NOX SAMPLE  METER READING/SCALE           61.9/2
   NOX SAMPLE  PPM                           61.9
   NOX BACKGRD METER READING/SCALE            2.4/2
   NOX BACKGRD PPM                            2.4
   HC  CONCENTRATION PPM                      10
   CO  CONCENTRATION PPM                      41
   CO2 CONCENTRATION PCT                     1.65
   NOX CONCENTRATION PPM                     54.8
   SO2 COCENTRATION PPM                      0.0
   HC  MASS (GRAMS)                           .88
   CO  MASS (GRAMS)                          7.29
   CO2 MASS (GRAMS)                        4599.15
   NOX MASS (GRAMS)                         17.38
   SO2 MASS (GRAMS)                          0.00

 HC  GRAMS/KILOMETRE       .04
 CO  GRAMS/KILOMETRE       .34
 CO2 GRAMS/KILOMETRE    212
 NOX GRAMS/KILOMETRE       .80
 SO2 GRAMS/KILOMETRE      0.00

 HC  GRAMS/KG OF FUEL    .60     HC  GRAMS/MIN       .0
 CO  GRAMS/KG OF FUEL    5.0     CO  GRAMS/MIN      .3
 CO2 GRAMS/KG OF FUEL   3163     CO2 GRAMS/MIN     200
 NOX GRAMS/KG OF FUEL  11.95     NOX GRAMS/MIN      .76
 SO2 GRAMS/KG OF FUEL   0.00     SO2 GRAMS/MIN    0.00

 CARBON BALANCE FUEL CONSUMPTION =  7.89 LITRES PER HUNDRED KILOMETRES
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        TABLE E-21.  EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
                              VEHICLE NUMBER

DATE  7/ 1/76                  TIME     -0 HRS.        TEST NO.  1
MODEL  1975 MERCEDES 300D FET FTY STOCK                ENGINE 3.0 LITRE I   5 CYL.
DRIVER   DT                    TEST WT.  1587 KG.      GVW    0 KG
WET BULB TEMP  19 C            DRY BULB TEMP  27 C     REL. HUM.  50.8 PCT
SPEC. HUM.  11.4 GRAM/KG       BARO.  740.4 MM  HG.    MEASURED FUEL  0.00 KG
DISTANCE  16.476 KM            FUEL 847.3 G/LITRE    FUEL HC  RATIO 1.844

  RUN DURATION           12.78 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 304.8  MM  H2O
  BLOWER INLET TEMP.     48  DEG. C
  DYNO REVOLUTIONS     23944
  BLOWER REVOLUTIONS    11396
  BLOWER CU. CM /REV.  8410

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE            13.5/2
   HC   SAMPLE  PPM                              27
   HC   BACKGRD METER READING/SCALE             3.0/2
   HC   BACKGRD PPM                               6
   CO   SAMPLE  METER READING/SCALE            18.3/*
   CO   SAMPLE  PPM                              63
   CO   BACKGRD METER READING/SCALE              .2/*
   CO   BACKGRD PPM                               1
   CO2  SAMPLE  METER READING/SCALE            75.1/2
   CO2  SAMPLE  PERCENT                        2.31
   CO2  BACKGRD METER READING/SCALE             2.3/2
   CO2  BACKGRD PERCENT                         .06
   NOX  SAMPLE  METER READING/SCALE            91.4/2
   NOX  SAMPLE  PPM                            91.4
   NOX  BACKGRD METER READING/SCALE             4.5/2
   NOX  BACKGRD PPM                             4.5
   HC   CONCENTRATION PPM                        22
   CO   CONCENTRATION PPM                        59
   CO2  CONCENTRATION PCT                      2.26
   NOX  CONCENTRATION PPM                      87.7
   SO2  COCENTRATION PPM                        0.0
   HC   MASS (GRAMS)                           1.05
   CO   MASS (GRAMS)                           5.68
   CO2  MASS (GRAMS)                        3448.31
   NOX  MASS (GRAMS)                          14.23
   SO2  MASS (GRAMS)                           0.00

 HC  GRAMS/KILOMETRE       .06
 CO  GRAMS/KILOMETRE       .34
 CO2 GRAMS/KILOMETRE    209
 NOX GRAMS/KILOMETRE       .86
 SO2 GRAMS/KILOMETRE      0.00

 HC  GRAMS/KG OF FUEL    .96     HC   GRAMS/MIN        .1
 CO  GRAMS/KG OF FUEL    5.2     CO   GRAMS/MIN       .4
 CO2 GRAMS/KG OF FUEL   3162     CO2  GRAMS/MIN     270
 NOX GRAMS/KG OF FUEL  13.05     NOX  GRAMS/MIN    1.11
 SO2 GRAMS/KG OF FUEL   0.00     SO2  GRAMS/MIN    0.00

 CARBON BALANCE FUEL CONSUMPTION =  7.81 LITRES PER HUNDRED KILOMETRES
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        TABLE E-22.  EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
                             VEHICLE NUMBER

                                                     TEST NO.  2
DATE  7/ 2/76                TIME    -0 HRS.         ENGINE 3.0 LITRE I  5 CYL.
MODEL  1975 MERCEDES 300-D    FET FTY STOCK          GVW    0 KG
DRIVER   BY                  TEST WT.  1587 KG.      REL. HUM.  62.8 PCT
WET BULB TEMP  19 C          DRY BULB TEMP  24 C     MEASURED FUEL  0.00 KG
SPEC. HUM.  12.3 GRAM/KG     BARO.  740.9 MM  HG.
DISTANCE  16.476 KM          FUEL 847.3 G/LITRE   FUEL HC  RATIO 1.844

  RUN DURATION          12.76 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H20
  BLOWER DIF.  PRESS. 304.8  MM  H20
  BLOWER INLET TEMP.     45  DEG. C
  DYNO REVOLUTIONS     23771
  BLOWER REVOLUTIONS   11376
  BLOWER CU. CM /REV.  8430

  BAG RESULTS
   HC  SAMPLE  METER READING/SCALE            19.2/2
   HC  SAMPLE  PPM                              38
   HC  BACKGRD METER READING/SCALE             7.0/2
   HC  BACKGRD PPM                              14
   CO  SAMPLE  METER READING/SCALE            18.8/*
   CO  SAMPLE  PPM                              65
   CO  BACKGRD METER READING/SCALE              .6/*
   CO  BACKGRD PPM                              2
   CO2 SAMPLE  METER READING/SCALE            73.5/2
   CO2 SAMPLE  PERCENT                        2.25
   CO2 BACKGRD METER READING/SCALE             3.1/2
   CO2 BACKGRD PERCENT                         .08
   NOX SAMPLE  METER READING/SCALE            90.0/2
   NOX SAMPLE  PPM                            90.0
   NOX BACKGRD METER READING/SCALE             4.4/2
   NOX BACKGRD PPM                             4.4
   HC  CONCENTRATION PPM                       27
   CO  CONCENTRATION PPM                       59
   CO2 CONCENTRATION PCT                     2.18
   NOX CONCENTRATION PPM                     86.3
   SO2 COCENTRATION PPM                      0.0
   HC  MASS (GRAMS)                          1.30
   CO  MASS (GRAMS)                          5.80
   CO2 MASS (GRAMS)                       3372.54
   NOX MASS (GRAMS)                         14.65
   SO2 MASS (GRAMS)                          0.00

 HC  GRAMS/KILOMETRE       .08
 CO  GRAMS/KILOMETRE       .35
 CO2 GRAMS/KILOMETRE    205
 NOX GRAMS/KILOMETRE       .89
 SO2 GRAMS/KILOMETRE      0.00

 HC  GRAMS/KG OF FUEL   1.21     HC  GRAMS/MIN        .1
 CO  GRAMS/KG OF FUEL    5.4     CO  GRAMS/MIN       .5
 CO2 GRAMS/KG OF FUEL   3161     CO2 GRAMS/MIN     264
 NOX GRAMS/KG OF FUEL  13.73     NOX GRAMS/MIN     1.15
 SO2 GRAMS/KG OF FUEL   0.00     SO2 GRAMS/MIN     0.00

 CARBON BALANCE FUEL CONSUMPTION =  7.64 LITRES PER HUNDRED KILOMETRES
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TABLE E-23. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

```
DATE  7/ 6/76                TIME     -0 HRS.          TEST NO.  1
MODEL  1975 MERCEDES 300D    FET PART TRAPS            ENGINE 3.0 LITRE I   5 CYL.
DRIVER   DT                  TEST WT.  1587 KG.        GVW    0 KG
WET BULB TEMP  19 C          DRY BULB TEMP  24 C       REL. HUM.  66.2 PCT
SPEC. HUM.  12.6 GRAM/KG     BARO.  741.2 MM  HG.      MEASURED FUEL  0.00 KG
DISTANCE  16.476 KM          FUEL 847.3 G/LITRE     FUEL HC  RATIO 1.844

  RUN DURATION          11.83 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 304.8  MM  H2O
  BLOWER INLET TEMP.      44  DEG. C
  DYNO REVOLUTIONS     22322
  BLOWER REVOLUTIONS     10550
  BLOWER CU. CM /REV.  8434

  BAG RESULTS
   HC  SAMPLE  METER READING/SCALE            11.6/2
   HC  SAMPLE  PPM                               23
   HC  BACKGRD METER READING/SCALE             5.7/2
   HC  BACKGRD PPM                               11
   CO  SAMPLE  METER READING/SCALE            18.4/*
   CO  SAMPLE  PPM                               64
   CO  BACKGRD METER READING/SCALE             1.0/*
   CO  BACKGRD PPM                                3
   CO2 SAMPLE  METER READING/SCALE            72.1/2
   CO2 SAMPLE  PERCENT                         2.20
   CO2 BACKGRD METER READING/SCALE             2.5/2
   CO2 BACKGRD PERCENT                          .07
   NOX SAMPLE  METER READING/SCALE            84.8/2
   NOX SAMPLE  PPM                             84.8
   NOX BACKGRD METER READING/SCALE             3.4/2
   NOX BACKGRD PPM                              3.4
   HC  CONCENTRATION PPM                         14
   CO  CONCENTRATION PPM                         57
   CO2 CONCENTRATION PCT                       2.15
   NOX CONCENTRATION PPM                       82.0
   SO2 COCENTRATION PPM                         0.0
   HC  MASS (GRAMS)                             .62
   CO  MASS (GRAMS)                            5.17
   CO2 MASS (GRAMS)                         3082.24
   NOX MASS (GRAMS)                           13.04
   SO2 MASS (GRAMS)                            0.00

 HC  GRAMS/KILOMETRE       .04
 CO  GRAMS/KILOMETRE       .31
 CO2 GRAMS/KILOMETRE    187
 NOX GRAMS/KILOMETRE       .79
 SO2 GRAMS/KILOMETRE      0.00

 HC  GRAMS/KG OF FUEL     .63     HC  GRAMS/MIN       .1
 CO  GRAMS/KG OF FUEL     5.3     CO  GRAMS/MIN       .4
 CO2 GRAMS/KG OF FUEL    3163     CO2 GRAMS/MIN    261
 NOX GRAMS/KG OF FUEL   13.38     NOX GRAMS/MIN    1.10
 SO2 GRAMS/KG OF FUEL    0.00     SO2 GRAMS/MIN    0.00
```

TABLE E-24. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

```
DATE  7/ 7/76                  TIME     -0 HRS.         TEST NO.  2
MODEL  1975 MERCEDES 300D      FET PART TRAPS           ENGINE 3.0 LITRE I  5 CYL.
DRIVER   TJ                    TEST WT.  1587 KG.       GVW    0 KG
WET BULB TEMP  21 C            DRY BULB TEMP  24 C      REL. HUM.  74.1 PCT
SPEC. HUM.  14.1 GRAM/KG       BARO.  742.7 MM  HG.     MEASURED FUEL  0.00 KG
DISTANCE  16.476 KM            FUEL 847.3 G/LITRE   FUEL HC  RATIO 1.844

  RUN DURATION            12.65 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 312.4  MM  H2O
  BLOWER INLET TEMP.      46  DEG. C
  DYNO REVOLUTIONS    23743
  BLOWER REVOLUTIONS    11279
  BLOWER CU. CM /REV.  8414

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE           15.9/1
   HC   SAMPLE  PPM                             16
   HC   BACKGRD METER READING/SCALE             9.5/1
   HC   BACKGRD PPM                             10
   CO   SAMPLE  METER READING/SCALE            18.6/*
   CO   SAMPLE  PPM                             64
   CO   BACKGRD METER READING/SCALE             1.8/*
   CO   BACKGRD PPM                              6
   CO2 SAMPLE  METER READING/SCALE            82.0/2
   CO2 SAMPLE  PERCENT                        2.56
   CO2 BACKGRD METER READING/SCALE              2.3/2
   CO2 BACKGRD PERCENT                         .06
   NOX SAMPLE  METER READING/SCALE            94.1/2
   NOX SAMPLE  PPM                            94.1
   NOX BACKGRD METER READING/SCALE              5.2/2
   NOX BACKGRD PPM                             5.2
   HC   CONCENTRATION PPM                         8
   CO   CONCENTRATION PPM                        55
   CO2 CONCENTRATION PCT                      2.51
   NOX CONCENTRATION PPM                      89.9
   SO2 COCENTRATION PPM                       0.0
   HC   MASS (GRAMS)                           .39
   CO   MASS (GRAMS)                          5.32
   CO2 MASS (GRAMS)                        3837.86
   NOX MASS (GRAMS)                          16.06
   SO2 MASS (GRAMS)                           0.00

HC   GRAMS/KILOMETRE       .02
CO   GRAMS/KILOMETRE       .32
CO2 GRAMS/KILOMETRE    233
NOX GRAMS/KILOMETRE       .97
SO2 GRAMS/KILOMETRE      0.00

HC   GRAMS/KG OF FUEL    .32     HC   GRAMS/MIN       .0
CO   GRAMS/KG OF FUEL    4.4     CO   GRAMS/MIN      .4
CO2 GRAMS/KG OF FUEL   3165     CO2 GRAMS/MIN    303
NOX GRAMS/KG OF FUEL  13.24     NOX GRAMS/MIN   1.27
SO2 GRAMS/KG OF FUEL   0.00     SO2 GRAMS/MIN   0.00

CARBON BALANCE FUEL CONSUMPTION =  8.68 LITRES PER HUNDRED KILOMETRES
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        TABLE E-25.  EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
                             VEHICLE NUMBER

DATE  7/ 8/76                TIME    -0 HRS.          TEST NO.  3
MODEL  1975 MERCEDES 300D    FET PART TRAPS           ENGINE 3.0 LITRE I  5 CYL.
DRIVER   DT                  TEST WT.  1587 KG.       GVW    0 KG
WET BULB TEMP  20 C          DRY BULB TEMP  24 C      REL. HUM.  70.1 PCT
SPEC. HUM.  13.3 GRAM/KG     BARO.  741.4 MM  HG.     MEASURED FUEL  0.00 KG
DISTANCE  16.476 KM          FUEL 847.3 G/LITRE   FUEL HC  RATIO 1.844

  RUN DURATION          12.64 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 317.5  MM  H2O
  BLOWER INLET TEMP.     45  DEG. C
  DYNO REVOLUTIONS    23226
  BLOWER REVOLUTIONS    11275
  BLOWER CU. CM /REV.  8413

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE             21.4/1
   HC   SAMPLE  PPM                               21
   HC   BACKGRD METER READING/SCALE              8.9/1
   HC   BACKGRD PPM                                9
   CO   SAMPLE  METER READING/SCALE             16.8/*
   CO   SAMPLE  PPM                               58
   CO   BACKGRD METER READING/SCALE               .6/*
   CO   BACKGRD PPM                                2
   CO2  SAMPLE  METER READING/SCALE             75.1/2
   CO2  SAMPLE  PERCENT                         2.31
   CO2  BACKGRD METER READING/SCALE              3.2/2
   CO2  BACKGRD PERCENT                          .08
   NOX  SAMPLE  METER READING/SCALE             85.7/2
   NOX  SAMPLE  PPM                             85.7
   NOX  BACKGRD METER READING/SCALE              2.8/2
   NOX  BACKGRD PPM                              2.8
   HC   CONCENTRATION PPM                         14
   CO   CONCENTRATION PPM                         52
   CO2  CONCENTRATION PCT                       2.24
   NOX  CONCENTRATION PPM                       83.4
   SO2  COCENTRATION PPM                         0.0
   HC   MASS (GRAMS)                             .67
   CO   MASS (GRAMS)                            5.05
   CO2  MASS (GRAMS)                         3423.41
   NOX  MASS (GRAMS)                           14.51
   SO2  MASS (GRAMS)                            0.00

 HC  GRAMS/KILOMETRE      .04
 CO  GRAMS/KILOMETRE      .31
 CO2 GRAMS/KILOMETRE   208
 NOX GRAMS/KILOMETRE      .88
 SO2 GRAMS/KILOMETRE     0.00

 HC  GRAMS/KG OF FUEL    .62      HC  GRAMS/MIN       .1
 CO  GRAMS/KG OF FUEL    4.7      CO  GRAMS/MIN      .4
 CO2 GRAMS/KG OF FUEL   3164      CO2 GRAMS/MIN    271
 NOX GRAMS/KG OF FUEL  13.41      NOX GRAMS/MIN   1.15
 SO2 GRAMS/KG OF FUEL   0.00      SO2 GRAMS/MIN   0.00
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GASEOUS EMISSIONS
AT 8045 KM (5000 MILES)
OF MVMA ACCUMULATION ON VEHICLE;

FACTORY STOCK AND A-1F, A-1R AND TAV$_s$
PARTICULATE TRAP SYSTEM

		km	miles
A-1F	Total	10409	6469
	MVMA	8045	5000
A-1R	Total	11220	6973
	MVMA	8045	5000

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                              TABLE E-26.           VEHICLE EMISSION RESULTS
                                     1975  LIGHT DUTY EMISSIONS TEST

                                             DATE 10/ 5/76                 MFGR. CODE    -0                  YR. 1975
UNIT NO.              TEST NO. 1             ENGINE    3.00 LITRE 5 CYL.   TEST WT.  1587 KG                 ROAD LOAD    8.4 KW
VEHICLE MODEL  MERCEDES-300D 75              COMMENTS  3 BAG 150 IN. HP
TEST TYPE  FTP FTY 5K MILES
                                                                         WET BULB TEMP  16.1 DEG. C
BAROMETER 734.90 MM OF HG.                                                ABS. HUMIDITY  10.1 MILLIGRAMS/KG
DRY BULB TEMP.    20.0 DEG. C
REL. HUMIDITY      67 PCT.
EXHAUST EMISSIONS
                                                                         BLOWER INLET PRESS., G1 254.0 MM. H2O
                                                                         BLOWER INLET TEMP.    43 DEG. C
    BLOWER DIF. PRESS., G2, 304.8 MM. H2O

                                                                                    3
    BAG RESULTS                                           1               2         7502
    BAG NO.                                              7515           12881       36.7/1
    BLOWER REVOLUTIONS                                   26.6/2          14.7/2      37
    HC    SAMPLE   METER READING/SCALE                     53              29       10.0/1
    HC    SAMPLE   PPM                                   14.0/2           9.5/2      10
    HC    BACKGRD METER READING/SCALE                      28              19       51.5/*
    HC    BACKGRD PPM                                    52.6/*          75.3/*      49
    CO    SAMPLE   METER READING/SCALE                    114              74       13.5/*
    CO    SAMPLE   PPM                                   38.3/*          25.2/*      13
    CO    BACKGRD METER READING/SCALE                      80              50       72.7/3
    CO    BACKGRD PPM                                    82.6/3          49.3/3      1.32
    CO2   SAMPLE   METER READING/SCALE                    1.52             .85       4.1/3
    CO2   SAMPLE   PERCENT                                6.1/3           5.6/3      .06
    CO2   BACKGRD METER READING/SCALE                      .09             .09      46.9/2
    CO2   BACKGRD PERCENT                                49.3/2          29.6/2      46.9
    NOX   SAMPLE   METER READING/SCALE                   49.3            29.6        .8/2
    NOX   SAMPLE   PPM                                    3.5/2           2.3/2      .8
    NOX   BACKGRD METER READING/SCALE                     3.5             2.3
    NOX   BACKGRD PPM
                                                                                     28
                                                           28              12        35
    HC    CONCENTRATION PPM                                39              25       1.26
    CO    CONCENTRATION PPM                               1.44             .77      46.2
    CO2   CONCENTRATION PCT                              46.2            27.4        .89
    NOX   CONCENTRATION PPM                                .91             .64      2.28
    HC    MASS GRAMS                                     2.54            2.82     1292.07
    CO    MASS GRAMS                                  1976.48         1357.98       4.81
    CO2   MASS GRAMS                                     4.82            4.91        .89
    NOX   MASS GRAMS                                      .91             .64
     HC    MASS MG

     WEIGHTED MASS HC        .13 GRAMS/KILOMETRE
     WEIGHTED MASS CO        .43 GRAMS/KILOMETRE
     WEIGHTED MASS CO2    226.17 GRAMS/KILOMETRE
     WEIGHTED MASS NOX       .81 GRAMS/KILOMETRE

    CARBON BALANCE FUEL CONSUMPTION =  8.44 LITRES PER HUNDRED KILOMETRES
    TOTAL CVS FLOW =    207.0 STD. CU. METRES
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                    TABLE E-27.         VEHICLE EMISSION RESULTS
                          1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.              TEST NO. 1        DATE  9/30/76                MFGR. CODE   -0               YR. 1975
VEHICLE MODEL  MERCEDES 300D            ENGINE    3.00 LITRE 5 CYL.  TEST WT.  1587 KG             ROAD LOAD   8.4 KW
TEST TYPE FTP TRAPS 5K MILES            COMMENTS  3 BAG

BAROMETER 743.46 MM OF HG.                                           WET BULB TEMP  15.6 DEG. C
DRY BULB TEMP.    22.2 DEG. C                                         ABS. HUMIDITY   8.4 MILLIGRAMS/KG
REL. HUMIDITY      49 PCT.
EXHAUST EMISSIONS

                                                                     BLOWER INLET PRESS., G1 254.0 MM. H20
    BLOWER DIF. PRESS., G2, 317.5 MM. H20                            BLOWER INLET TEMP.   96 DEG. C

    BAG RESULTS
    BAG NO.                                    1            2            3
    BLOWER REVOLUTIONS                       7519        12884         7526
    HC    SAMPLE  METER READING/SCALE        38.6/1       18.0/1       20.5/1
    HC    SAMPLE  PPM                          39           18           20
    HC    BACKGRD METER READING/SCALE        13.5/1       11.5/1       16.5/1
    HC    BACKGRD PPM                          13           11           16
    CO    SAMPLE  METER READING/SCALE        57.0/*       35.7/*       44.9/*
    CO    SAMPLE  PPM                          54           33           42
    CO    BACKGRD METER READING/SCALE         1.7/*        2.4/*        1.2/*
    CO    BACKGRD PPM                           2            2            1
    CO2   SAMPLE  METER READING/SCALE        93.2/3       53.8/3       79.6/3
    CO2   SAMPLE  PERCENT                    1.75          .94         1.46
    CO2   BACKGRD METER READING/SCALE         3.5/3        4.3/3        3.6/3
    CO2   BACKGRD PERCENT                     .05          .07          .06
    NOX   SAMPLE  METER READING/SCALE        61.6/2       33.7/2       56.1/2
    NOX   SAMPLE  PPM                        61.6         33.7         56.1
    NOX   BACKGRD METER READING/SCALE         1.0/2         .8/2         .7/2
    NOX   BACKGRD PPM                         1.0           .8           .7

    HC    CONCENTRATION PPM                    27            7            6
    CO    CONCENTRATION PPM                    50           30           39
    CO2   CONCENTRATION PCT                  1.70          .88         1.41
    NOX   CONCENTRATION PPM                  60.7         33.0         55.5
    HC    MASS GRAMS                          .86          .40          .18
    CO    MASS GRAMS                         3.24         3.32         2.54
    CO2   MASS GRAMS                      1729.44      1539.12      1439.00
    NOX   MASS GRAMS                         5.98         5.56         5.46
     HC    MASS MG                            .86          .40          .18

    WEIGHTED MASS HC        .07 GRAMS /KILOMETRE
    WEIGHTED MASS CO        .51 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    256.72 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       .93 GRAMS/KILOMETRE

   CARBON BALANCE FUEL CONSUMPTION =  9.58 LITRES PER HUNDRED KILOMETRES
   TOTAL CVS FLOW =   205.7 STD. CU. METRES
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                         TABLE E-28.          VEHICLE EMISSION RESULTS
                              1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.  111       TEST NO. 1          DATE 10/ 5/76                    MFGR. CODE   -0              YR. 1975
VEHICLE MODEL  MERCEDES 300D            ENGINE    3.00 LITRE 5 CYL.      TEST WT.  1587 KG            ROAD LOAD   8.4 KW
TEST TYPE FTPH FTY  5K MILES            COMMENTS  2 BAG 150 IN. HP

BAROMETER 739.90 MM OF HG.                                              WET BULB TEMP  16.1 DEG. C
DRY BULB TEMP.   20.0 DEG. C                                             ABS. HUMIDITY  10.1 MILLIGRAMS/KG
REL. HUMIDITY     67 PCT.
EXHAUST EMISSIONS

                                                                        BLOWER INLET PRESS., G1 254.0 MM. H2O
   BLOWER DIF. PRESS., G2, 304.8 MM. H2O                                BLOWER INLET TEMP.   46 DEG. C

   BAG RESULTS
   BAG NO.                                      1           2           3
   BLOWER REVOLUTIONS                         7502       12881        7502
   HC   SAMPLE  METER READING/SCALE          36.7/1      14.7/2      36.7/1
   HC   SAMPLE  PPM                            37          29          37
   HC   BACKGRD METER READING/SCALE          10.1/1       9.5/2      10.1/1
   HC   BACKGRD PPM                            10          19          10
   CO   SAMPLE  METER READING/SCALE          51.5/*      75.3/*      51.5/*
   CO   SAMPLE  PPM                            49          74          49
   CO   BACKGRD METER READING/SCALE          13.5/*      25.2/*      13.5/*
   CO   BACKGRD PPM                            13          50          13
   CO2  SAMPLE  METER READING/SCALE          72.7/3      49.3/3      72.7/3
   CO2  SAMPLE  PERCENT                      1.32         .85        1.32
   CO2  BACKGRD METER READING/SCALE           4.1/3       5.6/3       4.1/3
   CO2  BACKGRD PERCENT                       .06         .09         .06
   NOX  SAMPLE  METER READING/SCALE          46.9/2      29.6/2      46.9/2
   NOX  SAMPLE  PPM                          46.9        29.6        46.9
   NOX  BACKGRD METER READING/SCALE            .8/2       2.3/2        .8/2
   NOX  BACKGRD PPM                            .8         2.3          .8

   HC   CONCENTRATION PPM                      28          12          28
   CO   CONCENTRATION PPM                      35          25          35
   CO2  CONCENTRATION PCT                    1.26         .77        1.26
   NOX  CONCENTRATION PPM                    46.2        27.4        46.2
   HC   MASS GRAMS                            .88         .63         .88
   CO   MASS GRAMS                           2.26        2.79        2.26
   CO2  MASS GRAMS                        1278.44     1343.65     1278.44
   NOX  MASS GRAMS                           4.76        4.86        4.76
    HC   MASS MG                              .88         .63         .88

   WEIGHTED MASS HC        .12  GRAMS/KILOMETRE
   WEIGHTED MASS CO        .42 GRAMS/KILOMETRE
   WEIGHTED MASS CO2   217.28 GRAMS/KILOMETRE
   WEIGHTED MASS NOX       .80 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  8.11 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =   204.7 STD. CU. METRES
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                        TABLE E-29.          VEHICLE EMISSION RESULTS
                              1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.              TEST NO. 3         DATE 10/ 5/76                   MFGR. CODE   -0               YR. 1975
VEHICLE MODEL  MERCEDES 300D             ENGINE    0.00 LITRE 5 CYL.     TEST WT.  1587 KG             ROAD LOAD    8.4 KW
TEST TYPE FTPH FTY 5K MILES              COMMENTS  2 BAG NORMAL HP

BAROMETER 739.65 MM OF HG.                                    WET BULB TEMP  16.1 DEG. C
DRY BULB TEMP.    21.7 DEG. C                                  ABS. HUMIDITY    9.4 MILLIGRAMS/KG
REL. HUMIDITY      56 PCT.
EXHAUST EMISSIONS
                                                              BLOWER INLET PRESS., G1 254.0 MM. H2O
    BLOWER DIF. PRESS., G2, 317.5 MM. H2O                     BLOWER INLET TEMP.    43 DEG. C

    BAG RESULTS
    BAG NO.                                    1            2             3
    BLOWER REVOLUTIONS                      7513        12901          7513
    HC   SAMPLE  METER READING/SCALE      23.6/1       19.9/1        23.6/1
    HC   SAMPLE  PPM                          24           20            24
    HC   BACKGRD METER READING/SCALE      12.0/1       14.0/1        12.0/1
    HC   BACKGRD PPM                          12           14            12
    CO   SAMPLE  METER READING/SCALE      44.6/*       34.2/*        44.6/*
    CO   SAMPLE  PPM                          42           32            42
    CO   BACKGRD METER READING/SCALE       3.4/*        1.5/*         3.4/*
    CO   BACKGRD PPM                           3            1             3
    CO2  SAMPLE  METER READING/SCALE      72.3/3       50.7/3        72.3/3
    CO2  SAMPLE  PERCENT                    1.31          .88          1.31
    CO2  BACKGRD METER READING/SCALE       3.9/3        3.9/3         3.9/3
    CO2  BACKGRD PERCENT                     .06          .06           .06
    NOX  SAMPLE  METER READING/SCALE      43.7/2       28.4/2        43.7/2
    NOX  SAMPLE  PPM                        43.7         28.4          43.7
    NOX  BACKGRD METER READING/SCALE       1.2/2         .8/2         1.2/2
    NOX  BACKGRD PPM                         1.2           .8           1.2

    HC   CONCENTRATION PPM                    13            7            13
    CO   CONCENTRATION PPM                    37           29            37
    CO2  CONCENTRATION PCT                  1.26          .82          1.26
    NOX  CONCENTRATION PPM                  42.6         27.7          42.6
    HC   MASS GRAMS                          .41          .38           .41
    CO   MASS GRAMS                         2.41         3.27          2.41
    CO2  MASS GRAMS                      1285.25      1447.98       1285.25
    NOX  MASS GRAMS                         4.34         4.83          4.34
     HC   MASS MG                            .41          .38           .41

    WEIGHTED MASS HC        .07 GRAMS /KILOMETRE
    WEIGHTED MASS CO        .47 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    226.49 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       .76 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  8.45 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =    206.7 STD. CU. METRES
```

TABLE E-30. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

```
DATE 10/ 5/76              TIME    -0 HRS.         TEST NO.  2
MODEL  1975 MERCEDES-300D FET FTY 5K MILES         ENGINE 3.0 LITRE I  5 CYL.
DRIVER   BP                TEST WT.  1587 KG.      GVW    0 KG
WET BULB TEMP  16 C        DRY BULB TEMP  22 C     REL. HUM.  53.2 PCT
SPEC. HUM.   9.1 GRAM/KG   BARO.  739.6 MM  HG.    MEASURED FUEL  0.00 KG
DISTANCE  16.476 KM        FUEL 847.3 G/LITRE   FUEL HC  RATIO 1.844

  RUN DURATION          12.77 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 317.5  MM  H2O
  BLOWER INLET TEMP.      46  DEG. C
  DYNO REVOLUTIONS     23947
  BLOWER REVOLUTIONS     11387
  BLOWER CU. CM /REV.  8405

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE             31.9/1
   HC   SAMPLE  PPM                               32
   HC   BACKGRD METER READING/SCALE              8.5/1
   HC   BACKGRD PPM                                9
   CO   SAMPLE  METER READING/SCALE             61.7/*
   CO   SAMPLE  PPM                               59
   CO   BACKGRD METER READING/SCALE              6.4/*
   CO   BACKGRD PPM                                6
   CO2  SAMPLE  METER READING/SCALE             49.9/2
   CO2  SAMPLE  PERCENT                         2.28
   CO2  BACKGRD METER READING/SCALE              1.6/2
   CO2  BACKGRD PERCENT                          .06
   NOX  SAMPLE  METER READING/SCALE             76.9/2
   NOX  SAMPLE  PPM                             76.9
   NOX  BACKGRD METER READING/SCALE              1.4/2
   NOX  BACKGRD PPM                              1.4
   HC   CONCENTRATION PPM                         25
   CO   CONCENTRATION PPM                         51
   CO2  CONCENTRATION PCT                       2.23
   NOX  CONCENTRATION PPM                       75.7
   SO2  COCENTRATION PPM                         0.0
   HC   MASS (GRAMS)                            1.20
   CO   MASS (GRAMS)                            4.92
   CO2  MASS (GRAMS)                         3416.81
   NOX  MASS (GRAMS)                           11.47
   SO2  MASS (GRAMS)                            0.00

HC   GRAMS/KILOMETRE        .07
CO   GRAMS/KILOMETRE        .30
CO2  GRAMS/KILOMETRE    207
NOX  GRAMS/KILOMETRE        .70
SO2  GRAMS/KILOMETRE       0.00

HC   GRAMS/KG OF FUEL    1.11      HC   GRAMS/MIN        .1
CO   GRAMS/KG OF FUEL     4.6      CO   GRAMS/MIN       .4
CO2  GRAMS/KG OF FUEL    3162      CO2  GRAMS/MIN      268
NOX  GRAMS/KG OF FUEL   10.62      NOX  GRAMS/MIN      .90
SO2  GRAMS/KG OF FUEL    0.00      SO2  GRAMS/MIN     0.00
```

TABLE E-31. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE

```
                        VEHICLE NUMBER

DATE  9/30/76                 TIME    -0 HRS.         TEST NO.  2
MODEL  1975 MERCEDES-300D FET TRAPS 5K                ENGINE 3.0 LITRE I  5 CYL.
DRIVER   6P                   TEST WT.  1587 KG.      GVW    0 KG
WET BULB TEMP  16 C           DRY BULB TEMP  23 C     REL. HUM.  43.6 PCT
SPEC. HUM.   7.9 GRAM/KG      BARO.  743.5 MM  HG.    MEASURED FUEL  0.00 KG
DISTANCE  16.476 KM           FUEL 847.3 G/LITRE   FUEL HC  RATIO 1.844

  RUN DURATION           12.78 MINUTES
  BLOWER INLET PRESS. 254.0  MM. H2O
  BLOWER DIF.  PRESS. 304.8  MM  H2O
  BLOWER INLET TEMP.     46  DEG. C
  DYNO REVOLUTIONS    23763
  BLOWER REVOLUTIONS    11400
  BLOWER CU. CM /REV.  8426

  BAG RESULTS
   HC   SAMPLE  METER READING/SCALE
   HC   SAMPLE  PPM                             28.3/1
   HC   BACKGRD METER READING/SCALE               28
   HC   BACKGRD PPM                             16.5/1
   CO   SAMPLE  METER READING/SCALE               16
   CO   SAMPLE  PPM                             70.6/*
   CO   BACKGRD METER READING/SCALE               39
   CO   BACKGRD PPM                              2.3/*
   CO2  SAMPLE  METER READING/SCALE                1
   CO2  SAMPLE  PERCENT                         51.1/2
   CO2  BACKGRD METER READING/SCALE             2.34
   CO2  BACKGRD PERCENT                          1.5/2
   NOX  SAMPLE  METER READING/SCALE               .05
   NOX  SAMPLE  PPM                             33.8/3
   NOX  BACKGRD METER READING/SCALE            101.4
   NOX  BACKGRD PPM                               .3/3
   HC   CONCENTRATION PPM                         .9
   CO   CONCENTRATION PPM                         15
   CO2  CONCENTRATION PCT                         36
   NOX  CONCENTRATION PPM                       2.30
   SO2  COCENTRATION PPM                       100.7
   HC   MASS (GRAMS)                            0.0
   CO   MASS (GRAMS)                             .71
   CO2  MASS (GRAMS)                            3.52
   NOX  MASS (GRAMS)                         3557.63
   SO2  MASS (GRAMS)                           14.83
                                                0.00

 HC   GRAMS/KILOMETRE       .04
 CO   GRAMS/KILOMETRE       .21
 CO2  GRAMS/KILOMETRE    216
 NOX  GRAMS/KILOMETRE       .90
 SO2  GRAMS/KILOMETRE      0.00

 HC   GRAMS/KG OF FUEL     .63      HC   GRAMS/MIN        .1
 CO   GRAMS/KG OF FUEL     3.1      CO   GRAMS/MIN      .3
 CO2  GRAMS/KG OF FUEL    3166      CO2  GRAMS/MIN     278
 NOX  GRAMS/KG OF FUEL   13.20      NOX  GRAMS/MIN    1.16
 SO2  GRAMS/KG OF FUEL    0.00      SO2  GRAMS/MIN    0.00

CARBON BALANCE FUEL CONSUMPTION =  8.05 LITRES PER HUNDRED KILOMETRES
```

GASEOUS EMISSIONS AT 16090 KM (10,000 MILES) OF MVMA ACCUMULATION ON VEHICLE;

FACTORY STOCK AND A-IF, A-IR AND TAV$_S$ PARTICULATE TRAP SYSTEM

		km	miles
A-IF	Total	14432	8970
	MVMA	12068	7500
A-IR	Total	15243	9475
	MVMA	12068	7500

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                        TABLE E-32.          VEHICLE EMISSION RESULTS
                                 1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.              TEST NO. 1          DATE 11/ 1/76                    MFGR. CODE   -0                 YR. 1975
VEHICLE MODEL  MERCEDES 300 D             ENGINE    3.00 LITRE 5 CYL.       TEST WT.  1587 KG              ROAD LOAD    8.4 KW
TEST TYPE  FACTORY STOCK                  COMMENTS  1975 FTP COLD 10000 MILE TEST 3 BAG

BAROMETER 749.05 MM OF HG.                                                  WET BULB TEMP  15.6 DEG. C
DRY BULB TEMP.    25.0 DEG. C                                                ABS. HUMIDITY   7.1 MILLIGRAMS/KG
REL. HUMIDITY       36 PCT.
EXHAUST EMISSIONS

                                                                            BLOWER INLET PRESS., G1 266.7 MM. H20
    BLOWER DIF. PRESS., G2, 317.5 MM. H20                                   BLOWER INLET TEMP.    43 DEG. C

    BAG RESULTS
    BAG NO.                                         1               2               3
    BLOWER REVOLUTIONS                           7504           12900            7502
    HC    SAMPLE  METER READING/SCALE          27.0/1          13.0/1          24.0/1
    HC    SAMPLE  PPM                              27              13              24
    HC    BACKGRD METER READING/SCALE           1.5/1           1.2/1           4.0/1
    HC    BACKGRD PPM                               2               1               4
    CO    SAMPLE  METER READING/SCALE          49.4/*          33.0/*          41.5/*
    CO    SAMPLE  PPM                              47              31              39
    CO    BACKGRD METER READING/SCALE           3.1/*           3.1/*           2.6/*
    CO    BACKGRD PPM                               3               3               3
    CO2   SAMPLE  METER READING/SCALE          35.8/2          21.6/2          30.7/2
    CO2   SAMPLE  PERCENT                        1.53             .86            1.28
    CO2   BACKGRD METER READING/SCALE           2.2/2           2.2/2           1.9/2
    CO2   BACKGRD PERCENT                         .08             .08             .07
    NOX   SAMPLE  METER READING/SCALE          59.2/2          36.5/2          55.6/2
    NOX   SAMPLE  PPM                            59.2            36.5            55.6
    NOX   BACKGRD METER READING/SCALE            .8/2            .8/2            .7/2
    NOX   BACKGRD PPM                              .8              .8              .7

    HC    CONCENTRATION PPM                        26              12              20
    CO    CONCENTRATION PPM                        42              27              35
    CO2   CONCENTRATION PCT                      1.45             .78            1.21
    NOX   CONCENTRATION PPM                      58.5            35.8            55.0
    HC    MASS GRAMS                              .83             .66             .66
    CU    MASS GRAMS                             2.76            3.06            2.31
    CO2   MASS GRAMS                          1503.91         1393.96         1254.52
    NOX   MASS GRAMS                             5.63            5.91            5.29
     HC    MASS MG                                .83             .66             .66

    WEIGHTED MASS HC        .12 GRAMS/KILOMETRE
    WEIGHTED MASS CO        .96 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    228.36 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       .94 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  8.52 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =    209.1 STD. CU. METRES
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                     TABLE E-33.           VEHICLE EMISSION RESULTS
                              1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.              TEST NO. 1       DATE 11/ 8/76                    MFGR. CODE   -0               YR. 1975
VEHICLE MODEL  MERCEDES 300-D          ENGINE   3.00 LITRE 5 CYL.       TEST WT.  1587 KG             ROAD LOAD   8.4 KW
TEST TYPE  TRAP SYSTEM                 COMMENTS  1975 FTP 10000 MILE TEST 3 BAG

BAROMETER 751.59 MM OF HG.                                              WET BULB TEMP  13.3 DEG. C
DRY BULB TEMP.   25.0 DEG. C                                             ABS. HUMIDITY   4.7 MILLIGRAMS/KG
REL. HUMIDITY     24 PCT.
EXHAUST EMISSIONS
                                                                        BLOWER INLET PRESS., G1 330.2 MM. H2O
    BLOWER DIF. PRESS., G2, 266.7 MM. H2O                               BLOWER INLET TEMP.   43 DEG. C

    BAG RESULTS
    BAG NO.                                         1              2              3
    BLOWER REVOLUTIONS                            7490          12936           7510
    HC   SAMPLE  METER READING/SCALE              24.9/1         17.6/1         19.0/1
    HC   SAMPLE  PPM                               25             18             19
    HC   BACKGRD METER READING/SCALE               6.5/1          6.0/1          7.5/1
    HC   BACKGRD PPM                                7              6              8
    CO   SAMPLE  METER READING/SCALE              48.7/*         31.6/*         40.7/*
    CO   SAMPLE  PPM                               46             29             38
    CO   BACKGRD METER READING/SCALE               3.8/*          2.0/*          1.2/*
    CO   BACKGRD PPM                                4              2              1
    CO2  SAMPLE  METER READING/SCALE              80.2/3         50.4/3         72.9/3
    CO2  SAMPLE  PERCENT                          1.47            .87           1.32
    CO2  BACKGRD METER READING/SCALE               3.8/3          4.4/3          5.0/3
    CO2  BACKGRD PERCENT                           .06            .07            .08
    NOX  SAMPLE  METER READING/SCALE              58.1/2         38.2/2         59.0/2
    NOX  SAMPLE  PPM                              58.1           38.2           59.0
    NOX  BACKGRD METER READING/SCALE               .6/2           .6/2           .6/2
    NOX  BACKGRD PPM                               .6             .6             .6

    HC   CONCENTRATION PPM                         19             12             12
    CO   CONCENTRATION PPM                         41             27             36
    CO2  CONCENTRATION PCT                        1.42            .81           1.25
    NOX  CONCENTRATION PPM                        57.6           37.6           58.5
    HC   MASS GRAMS                               .62            .68            .40
    CO   MASS GRAMS                               2.70           3.06           2.36
    CO2  MASS GRAMS                            1475.02        1454.11        1304.33
    NOX  MASS GRAMS                               5.18           5.85           5.27
     HC   MASS MG                                 .62            .68            .40

    WEIGHTED MASS HC        .10 GRAMS/KILOMETRE
    WEIGHTED MASS CO        .46 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    234.67 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       .92 GRAMS/KILOMETRE

   CARBON BALANCE FUEL CONSUMPTION =  8.76 LITRES PER HUNDRED KILOMETRES
   TOTAL CVS FLOW =   210.4 STD. CU. METRES
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                    TABLE  E-34.          VEHICLE EMISSION RESULTS
                         1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.  333        TEST NO. 1        DATE 11/ 1/76                MFGR. CODE   -0           YR. 1975
VEHICLE MODEL  MERCEDES 300D           ENGINE   3.00 LITRE 5 CYL.   TEST WT.  1587 KG        ROAD LOAD   8.4 KW
TEST TYPE  FACTORY STOCK               COMMENTS  1975 FTP COLD 10000 MILE TEST 2 BAG

BAROMETER 749.05 MM OF HG.                                   WET BULB TEMP  15.6 DEG. C
DRY BULB TEMP.   25.0 DEG. C                                  ABS. HUMIDITY   7.1 MILLIGRAMS/KG
REL. HUMIDITY      36 PCT.
EXHAUST EMISSIONS
                                                             BLOWER INLET PRESS., G1 266.7 MM. H2O
     BLOWER DIF. PRESS., G2, 317.5 MM. H2O                   BLOWER INLET TEMP.    43 DEG. C

     BAG RESULTS
     BAG NO.                                      1            2            3
     BLOWER REVOLUTIONS                        7504        12900         7504
     HC   SAMPLE  METER READING/SCALE        27.0/1       13.0/1       27.0/1
     HC   SAMPLE  PPM                        27           13           27
     HC   BACKGRD METER READING/SCALE         1.5/1        1.2/1        1.5/1
     HC   BACKGRD PPM                         2            1            2
     CO   SAMPLE  METER READING/SCALE        49.4/*       33.0/*       49.4/*
     CO   SAMPLE  PPM                        47           31           47
     CO   BACKGRD METER READING/SCALE         3.1/*        3.1/*        3.1/*
     CO   BACKGRD PPM                         3            3            3
     CO2  SAMPLE  METER READING/SCALE        35.8/2       21.6/2       35.8/2
     CO2  SAMPLE  PERCENT                    1.53          .86         1.53
     CO2  BACKGRD METER READING/SCALE         2.2/2        2.2/2        2.2/2
     CO2  BACKGRD PERCENT                     .08          .08          .08
     NOX  SAMPLE  METER READING/SCALE        59.2/2       36.5/2       59.2/2
     NOX  SAMPLE  PPM                        59.2         36.5         59.2
     NOX  BACKGRD METER READING/SCALE          .8/2         .8/2         .8/2
     NOX  BACKGRD PPM                          .8           .8           .8

     HC   CONCENTRATION PPM                  26           12           26
     CO   CONCENTRATION PPM                  42           27           42
     CO2  CONCENTRATION PCT                  1.45          .78         1.45
     NOX  CONCENTRATION PPM                  58.5         35.8         58.5
     HC   MASS GRAMS                          .83          .66          .83
     CO   MASS GRAMS                         2.76         3.06         2.76
     CO2  MASS GRAMS                      1503.91      1393.96      1503.91
     NOX  MASS GRAMS                         5.63         5.91         5.63
      HC   MASS MG                            .83          .66          .83

     WEIGHTED MASS HC        .12 GRAMS/KILOMETRE
     WEIGHTED MASS CO        .48 GRAMS/KILOMETRE
     WEIGHTED MASS CO2    240.14 GRAMS/KILOMETRF
     WEIGHTED MASS NOX       .96 GRAMS/KILOMETRE

    CARBON BALANCE FUEL CONSUMPTION =  8.96 LITRES PER HUNDRED KILOMETRES
    TOTAL CVS FLOW =   203.1 STD. CU. METRES
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                          TABLE E-35.           VEHICLE EMISSION RESULTS
                                1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.  ???        TEST NO. 1          DATE 11/ 1/76                  MFGR. CODE   -0              YR. 1975
VEHICLE MODEL  MERCFDES 300D             ENGINE   3.00 LITRE 5 CYL.      TEST WT.  1587 KG          ROAD LOAD    8.4 KW
TEST TYPE  FACTORY STOCK                 COMMENTS  1975 FTP HOT  10000 MILE TEST 2 BAG

BAROMETER 749.05 MM OF HG.                                          WET BULB TEMP  16.1 DEG. C
DRY BULB TEMP.   26.1 DEG. C                                         ABS. HUMIDITY   7.3 MILLIGRAMS/KG
REL. HUMIDITY     34 PCT.
EXHAUST EMISSIONS

                                                                    BLOWER INLET PRESS., G1 261.6 MM. H2O
    BLOWER DIF. PRESS., G2, 317.5 MM. H2O                           BLOWER INLET TEMP.   43 DEG. C

    BAG RESULTS
    BAG NO.                                      1              2              3
    BLOWER REVOLUTIONS                        7502          12908           7502
    HC    SAMPLE  METER READING/SCALE       23.0/1         17.0/1         23.0/1
    HC    SAMPLE  PPM                         23             17             23
    HC    BACKGRD METER READING/SCALE        4.0/1          5.0/1          4.0/1
    HC    BACKGRD PPM                          4              5              4
    CO    SAMPLE  METER READING/SCALE       41.5/*         33.5/*         41.5/*
    CO    SAMPLE  PPM                         39             31             39
    CO    BACKGRD METER READING/SCALE        2.6/*          2.2/*          2.6/*
    CO    BACKGRD PPM                          3              2              3
    CO2   SAMPLE  METER READING/SCALE       30.7/2         20.5/2         30.7/2
    CO2   SAMPLE  PERCENT                   1.28            .81           1.28
    CO2   BACKGRD METER READING/SCALE        1.9/2          1.9/2          1.9/2
    CO2   BACKGRD PERCENT                    .07            .07            .07
    NOX   SAMPLE  METER READING/SCALE       55.6/2         32.3/2         55.6/2
    NOX   SAMPLE  PPM                       55.6           32.3           55.6
    NOX   BACKGRD METER READING/SCALE         .7/2           .6/2           .7/2
    NOX   BACKGRD PPM                          .7             .6             .7

    HC    CONCENTRATION PPM                   19             12             19
    CO    CONCENTRATION PPM                   35             28             35
    CO2   CONCENTRATION PCT                 1.21            .75           1.21
    NOX   CONCENTRATION PPM                 55.0           31.7           55.0
    HC    MASS GRAMS                         .63            .69            .63
    CO    MASS GRAMS                        2.31           3.20           2.31
    CO2   MASS GRAMS                     1255.20        1327.90        1255.20
    NOX   MASS GRAMS                        5.31           5.28           5.31
     HC    MASS MG                           .63            .69            .63

    WEIGHTED MASS HC        .11 GRAMS/KILOMETRE
    WEIGHTED MASS CO        .46 GRAMS/KILOMETRE
    WEIGHTED MASS CO2    214.05 GRAMS/KILOMETRE
    WEIGHTED MASS NOX       .88 GRAMS/KILOMETRE

   CARBON BALANCE FUEL CONSUMPTION =  7.94 LITRES PER HUNDRED KILOMETRES
   TOTAL CVS FLOW =   209.2 STD. CU. METRES
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                         TABLE  E-36.          VEHICLE EMISSION RESULTS
                              1975  LIGHT DUTY EMISSIONS TEST

UNIT NO.  ;;;          TEST NO. 1         DATE 11/ 1/76                 MFGR. CODE   -0                      YR. 1975
VEHICLE MODEL  MERCEDES 300 D             ENGINE    3.00 LITRE 5 CYL.          TEST WT.  1587 KG             ROAD LOAD    8.4 KW
TEST TYPE  FACTORY STOCK                  COMMENTS  1975 FTP HOT 10000 MILE TEST 2 BAG R2

BAROMETER 748.54 MM OF HG.                                               WET BULB TEMP  16.1 DEG. C
DRY BULB TEMP.   26.7 DEG. C                                              ABS. HUMIDITY   7.1 MILLIGRAMS/KG
REL. HUMIDITY     32 PCT.
EXHAUST EMISSIONS
                                                                         BLOWER INLET PRESS., G1 271.8 MM. H2O
   BLOWER DIF. PRESS., G2, 322.6 MM. H2O                                 BLOWER INLET TEMP.    46 DEG. C

   BAG RESULTS
   BAG NO.                                        1             2             3
   BLOWER REVOLUTIONS                           7502          12906         7502
   HC    SAMPLE  METER READING/SCALE           15.0/1         12.0/1        15.0/1
   HC    SAMPLE  PPM                             15             12            15
   HC    BACKGRD METER READING/SCALE            4.3/1          4.5/1         4.3/1
   HC    BACKGRD PPM                              4              5             4
   CO    SAMPLE  METER READING/SCALE           33.7/*         25.5/*        33.7/*
   CO    SAMPLE  PPM                             31             24            31
   CO    BACKGRD METER READING/SCALE            1.5/*          2.0/*         1.5/*
   CO    BACKGRD PPM                              1              2             1
   CO2   SAMPLE  METER READING/SCALE           70.5/3         46.3/3        70.5/3
   CO2   SAMPLE  PERCENT                       1.27            .80          1.27
   CO2   BACKGRD METER READING/SCALE            2.0/3          3.4/3         2.0/3
   CO2   BACKGRD PERCENT                        .03            .05           .03
   NOX   SAMPLE  METER READING/SCALE           52.1/2         33.1/2        52.1/2
   NOX   SAMPLE  PPM                           52.1           33.1          52.1
   NOX   BACKGRD METER READING/SCALE            1.0/2           .8/2         1.0/2
   NOX   BACKGRD PPM                            1.0             .8           1.0

   HC    CONCENTRATION PPM                       11              8            11
   CO    CONCENTRATION PPM                       29             21            29
   CO2   CONCENTRATION PCT                     1.25            .75          1.25
   NOX   CONCENTRATION PPM                     51.2           32.3          51.2
   HC    MASS GRAMS                             .36            .43           .36
   CO    MASS GRAMS                            1.88           2.38          1.88
   CO2   MASS GRAMS                         1272.19        1311.63       1272.19
   NOX   MASS GRAMS                            4.85           5.27          4.85
    HC    MASS MG                               .36            .43           .36

   WEIGHTED MASS HC        .06 GRAMS/KILOMETRE
   WEIGHTED MASS CO        .35 GRAMS/KILOMETRE
   WEIGHTED MASS CO2    214.13 GRAMS/KILOMETRE
   WEIGHTED MASS NOX       .84 GRAMS/KILOMETRE

  CARBON BALANCE FUEL CONSUMPTION =  7.99 LITRES PER HUNDRED KILOMETRES
  TOTAL CVS FLOW =   206.5 STD. CU. METRES
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TABLE E-37. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

```
DATE 11/ 1/76               TIME     -0 HRS.        TEST NO.  1
MODEL  1975 MERCEDES 300D  FET                     ENGINE 3.0 LITRE     5 CYL.
DRIVER   BP                 TEST WT.  1587 KG.      GVW     0 KG
WET BULB TEMP  16 C         DRY BULB TEMP  26 C     REL. HUM.  31.3 PCT
SPEC. HUM.   6.7 GRAM/KG    BARO.  749.0 MM  HG.    MEASURED FUEL  0.00 KG

  RUN DURATION           12.77 MINUTES
  BLOWER INLET PRESS. 271.8  MM. H20
  BLOWER DIF.  PRESS. 322.6  MM  H20
  BLOWER INLET TEMP.     46  DEG. C
  DYNO REVOLUTIONS    23637
  BLOWER REVOLUTIONS    11389
  BLOWER CU. CM /REV.  8404

  BAG RESULTS
   HC  SAMPLE  METER READING/SCALE            20.0/1
   HC  SAMPLE  PPM                              20
   HC  BACKGRD METER READING/SCALE             4.0/1
   HC  BACKGRD PPM                               4
   CO  SAMPLE  METER READING/SCALE            62.6/*
   CO  SAMPLE  PPM                              60
   CO  BACKGRD METER READING/SCALE             3.5/*
   CO  BACKGRD PPM                               3
   CO2 SAMPLE  METER READING/SCALE            46.2/2
   CO2 SAMPLE  PERCENT                        2.07
   CO2 BACKGRD METER READING/SCALE             2.2/2
   CO2 BACKGRD PERCENT                         .08
   NOX SAMPLE  METER READING/SCALE            31.8/3
   NOX SAMPLE  PPM                            95.4
   NOX BACKGRD METER READING/SCALE              .4/3
   NOX BACKGRD PPM                             1.2
   HC  CONCENTRATION PPM                        17
   CO  CONCENTRATION PPM                        54
   CO2 CONCENTRATION PCT                      2.00
   NOX CONCENTRATION PPM                      94.4
   SO2 COCENTRATION PPM                        0.0
   HC  MASS (GRAMS)                            .81
   CO  MASS (GRAMS)                           5.34
   CO2 MASS (GRAMS)                        3105.46
   NOX MASS (GRAMS)                          13.43
   SO2 MASS (GRAMS)                           0.00

HC  GRAMS/KILOMETRE       .05
CO  GRAMS/KILOMETRE       .32
CO2 GRAMS/KILOMETRE    188
NOX GRAMS/KILOMETRE       .81
SO2 GRAMS/KILOMETRE      0.00

HC  GRAMS/KG OF FUEL    .81      HC  GRAMS/MIN        .1
CO  GRAMS/KG OF FUEL    5.4      CO  GRAMS/MIN       .4
CO2 GRAMS/KG OF FUEL   3126      CO2 GRAMS/MIN     243
NOX GRAMS/KG OF FUEL  13.52      NOX GRAMS/MIN    1.05
SO2 GRAMS/KG OF FUEL   0.00      SO2 GRAMS/MIN    0.00

CARBON BALANCE FUEL CONSUMPTION =  7.11 LITRES PER HUNDRED KILOMETRES
```

TABLE E-38. EXHAUST EMISSIONS FROM SINGLE BAG SAMPLE
VEHICLE NUMBER

```
DATE 11/ 6/76                  TIME    -0 HRS.          TEST NO.  2
MODEL  1975 MERCEDES 300-D FET TRAPS 10K               ENGINE 3.0 LITRE    5 CYL.
DRIVER   BP                    TEST WT.      0 KG.      GVW    0 KG
WET BULB TEMP  19 C            DRY BULB TEMP  27 C      REL. HUM.  50.6 PCT
SPEC. HUM.  11.2 GRAM/KG       BARO.  751.6 MM  HG.     MEASURED FUEL  0.00 KG
DISTANCE  16.476 KM            FUEL 847.3 G/LITRE    FUEL HC  RATIO 1.844

  RUN DURATION             12.77 MINUTES
  BLOWER INLET PRESS. 274.3  MM. H2O
  BLOWER DIF.  PRESS. 342.9  MM  H2O
  BLOWER INLET TEMP.     48  DEG. C
  DYNO REVOLUTIONS     23972
  BLOWER REVOLUTIONS     11387
  BLOWER CU. CM /REV.  8361

  BAG RESULTS
   HC  SAMPLE  METER READING/SCALE                   26.9/1
   HC  SAMPLE  PPM                                    27
   HC  BACKGRD METER READING/SCALE                    7.0/1
   HC  BACKGRD PPM                                    7
   CO  SAMPLE  METER READING/SCALE                   18.6/*
   CO  SAMPLE  PPM                                    60
   CO  BACKGRD METER READING/SCALE                     .6/*
   CO  BACKGRD PPM                                    2
   CO2 SAMPLE  METER READING/SCALE                   46.7/2
   CO2 SAMPLE  PERCENT                               2.10
   CO2 BACKGRD METER READING/SCALE                    1.9/2
   CO2 BACKGRD PERCENT                                .07
   NOX SAMPLE  METER READING/SCALE                   34.2/3
   NOX SAMPLE  PPM                                  102.6
   NOX BACKGRD METER READING/SCALE                     .4/3
   NOX BACKGRD PPM                                   1.2
   HC  CONCENTRATION PPM                              21
   CO  CONCENTRATION PPM                              55
   CO2 CONCENTRATION PCT                             2.04
   NOX CONCENTRATION PPM                            101.6
   SO2 COCENTRATION PPM                              0.0
   HC  MASS (GRAMS)                                  1.03
   CO  MASS (GRAMS)                                  5.34
   CO2 MASS (GRAMS)                               3128.82
   NOX MASS (GRAMS)                                 16.45
   SO2 MASS (GRAMS)                                  0.00

 HC  GRAMS/KILOMETRE       .06
 CO  GRAMS/KILOMETRE       .32
 CO2 GRAMS/KILOMETRE    190
 NOX GRAMS/KILOMETRE      1.00
 SO2 GRAMS/KILOMETRE      0.00

 HC  GRAMS/KG OF FUEL   1.02      HC  GRAMS/MIN        .1
 CO  GRAMS/KG OF FUEL    5.4      CO  GRAMS/MIN       .4
 CO2 GRAMS/KG OF FUEL   3161      CO2 GRAMS/MIN      245
 NOX GRAMS/KG OF FUEL  16.62      NOX GRAMS/MIN     1.29
 SO2 GRAMS/KG OF FUEL   0.00      SO2 GRAMS/MIN     0.00

 CARBON BALANCE FUEL CONSUMPTION =  7.09 LITRES PER HUNDRED KILOMETRES
```

APPENDIX F

ODOR DATA AND RELATED EMISSION MEASUREMENTS

MERCEDES 300D WITH AND WITHOUT PARTICULATE TRAPPING SYSTEM INSTALLED

TABLE F-1. COMPARISON OF ODOR RATINGS
(Mercedes 300D with Particulate Trap System)

Operating Condition	Date	"D" Composite	"B" Burnt	"O" Oily	"A" Aromatic	"P" Pungent
Inter Speed No Load	8/2/76	1.2	0.7	0.4	0.1	0.1
	8/4/76	1.4	1.0	0.4	0.3	0.2
	8/6/76	1.7	1.0	0.4	0.2	0.2
	Average	1.4	0.9	0.4	0.2	0.2
Inter Speed Mid Load	8/2/76	0.8	0.6	0.3	0.1	0.1
	8/4/76	1.2	0.9	0.3	0.1	0.1
	8/6/76	0.9	0.9	0.1	0.1	0
	Average	1.0	0.8	0.2	0.1	0.1
Inter Speed High Load	8/2/76	0.7	0.5	0.1	0.1	0
	8/4/76	1.4	0.9	0.5	0.2	0.2
	8/6/76	0.9	0.7	0	0.1	0.1
	Average	1.0	0.7	0.2	0.1	0.1
High Speed No Load	8/2/76	1.7	0.9	0.5	0.2	0.2
	8/4/76	1.1	0.9	0.4	0.2	0.1
	8/6/76	1.0	0.8	0.2	0.1	0
	Average	1.3	0.9	0.4	0.2	0.1
High Speed Mid Load	8/2/76	2.0	1.2	0.6	0.2	0.2
	8/4/76	2.0	1.0	0.7	0.2	0.4
	8/6/76	1.4	0.8	0.4	0.1	0.2
	Average	1.8	1.0	0.6	0.2	0.3
High Speed High Load	8/2/76	2.2	0.8	0.[illegible]	0.3	0.5
	8/4/76	2.7	1.0	0.9	0.4	0.6
	8/6/76	2.5	1.0	0.8	0.4	0.6
	Average	2.5	0.9	0.8	0.4	0.6
Idle	8/2/76	2.0	1.0	0.5	0.4	0.4
	8/4/76	1.3	0.9	0.4	0.3	0.2
	8/6/76	1.2	0.9	0.3	0.2	0
	Average	1.5	0.9	0.4	0.3	0.2
Idle-Accel	8/2/76	2.1	1.0	0.5	0.6	0.5
	8/4/76	1.4	1.0	0.5	0.4	0.3
	8/6/76	1.3	0.8	0.1	0.4	0.1
	Average	1.6	0.9	0.4	0.5	0.3
Acceleration	8/2/76	2.3	1.0	0.7	0.6	0.5
	8/4/76	2.1	1.0	0.8	0.3	0.5
	8/6/76	2.1	1.0	0.3	0.4	0.7
	Average	2.2	1.0	0.6	0.4	0.6
Deceleration	8/2/76	1.7	0.9	0.5	0.6	0.3
	8/4/76	1.0	0.8	0.3	0.2	0.1
	8/6/76	0.9	0.6	0.1	0.2	0
	Average	1.2	0.8	0.3	0.3	0.1
Cold Start	8/2/76	0.8	0.6	0	0.2	0
	8/4/76	0.8	0.5	0.1	0	0
	8/6/76	0.7	0.7	0.1	0	0
	Average	0.8	0.6	0.1	0.1	0

TABLE F-2. VEHICLE ODOR EVALUATION SUMMARY

Vehicle: Mercedes 300 D with A-IF, A-IR and TAV$_8$ Trap System
Date: August 2, 1976

Run No.	Operating Condition	"D" Composite	"B" Burnt	"O" Oily	"A" Aromatic	"P" Pungent
6.	Inter. Speed	1.6	0.9	0.6	0.1	0.3
11.	No Load	0	0	0	0	0
15.		2.0	1.3	0.6	0.1	0.1
	Average	1.2	0.7	0.4	0.1	0.1
2.	Inter. Speed	0	0	0	0	0
8.	Mid Load	1.3	0.7	0.6	0.1	0.1
18.		1.1	1.0	0.3	0.1	0.3
	Average	0.8	0.6	0.3	0.1	0.1
1.	Inter. Speed	0	0	0	0	0
9.	High Load	0.9	0.8	0.1	0	0
19.		1.1	0.8	0.3	0.3	0
	Average	0.7	0.5	0.1	0.1	0
5.	High Speed	1.6	0.9	0.7	0	0.1
12.	No Load	2.1	0.9	0.7	0.3	0.4
17.		1.4	1.0	0.1	0.4	0.1
	Average	1.7	0.9	0.5	0.2	0.2
7.	High Speed	1.7	0.9	0.9	0.1	0.1
14.	Mid Load	2.4	1.7	0.4	0.1	0.3
20.		2.0	0.9	0.4	0.4	0.3
	Average	2.0	1.2	0.6	0.2	0.2
3.	High Speed	0	0	0	0	0
13.	High Load	3.6	1.3	1.0	0.4	0.9
21.		3.0	1.1	1.0	0.4	0.6
	Average	2.2	0.8	0.7	0.3	0.5
4.	Idle	3.1	1.0	1.0	0.6	0.6
10.		1.6	0.9	0.3	0.3	0.3
16.		1.4	1.0	0.1	0.2	0.3
	Average	2.0	1.0	0.5	0.4	0.4
24.	Idle-Acceleration	2.1	1.0	0.4	0.5	0.5
26.		2.1	1.0	0.4	0.8	0.3
27.		2.6	1.0	0.8	0.6	0.8
32.		1.6	0.8	0.4	0.6	0.3
	Average	2.1	1.0	0.5	0.6	0.5
22.	Acceleration	2.3	1.0	0.9	0.8	0.4
25.		2.1	1.0	0.5	0.6	0.4
29.		2.1	1.0	0.8	0.4	0.4
31.		2.8	0.9	0.6	0.6	0.6
	Average	2.3	1.0	0.7	0.6	0.5
23.	Deceleration	1.4	0.5	0.3	0.9	0.4
28.		2.0	1.0	0.5	0.5	0.4
30.		2.0	1.0	0.6	0.6	0.4
33.		1.4	0.9	0.4	0.4	0.1
	Average	1.7	0.9	0.5	0.6	0.3
	Cold Start	0.8	0.6	0	0.2	0

TABLE F-3. VEHICLE ODOR EVALUATION SUMMARY

Vehicle: Mercedes 300D with A-IF, A-IR and TAV$_8$ Trap System
Date: August 4, 1976

Run No.	Operating Condition	"D" Composite	"B" Burnt	"O" Oily	"A" Aromatic	"P" Pungent
7.	Inter. Speed	1.8	1.0	0.6	0.4	0.3
11.	No Load	1.4	1.0	0.4	0.4	0.3
16.		1.1	0.9	0.2	0.1	0.1
	Average	1.4	1.0	0.4	0.3	0.2
4.	Inter. Speed	1.0	0.9	0.3	0.3	0.1
14.	Mid Load	1.1	0.8	0.3	0	0
20.		1.6	0.9	0.3	0.1	0.1
	Average	1.2	0.9	0.3	0.1	0.1
3.	Inter. Speed	1.4	0.9	0.5	0.1	0.1
13.	High Load	1.8	0.9	0.8	0.4	0.4
21.		1.1	0.9	0.3	0.1	0.1
	Average	1.4	0.9	0.5	0.2	0.2
5.	High Speed	1.0	0.9	0.4	0.3	0.1
10.	No Load	1.3	0.9	0.4	0.3	0.1
17.		1.1	0.8	0.4	0.1	0.1
	Average	1.1	0.9	0.4	0.2	0.1
2.	High Speed	2.5	1.0	1.0	0.1	0.6
8.	Mid Load	1.6	1.0	0.6	0.3	0.3
15.		1.8	1.0	0.6	0.1	0.3
	Average	2.0	1.0	0.7	0.2	0.4
1.	High Speed	2.4	1.0	0.9	0.4	0.4
9.	High Load	3.0	1.0	1.0	0.4	0.9
19.		2.8	1.0	0.9	0.5	0.6
	Average	2.7	1.0	0.9	0.4	0.6
6.	Idle	1.1	0.9	0.4	0.3	0.1
12.		1.6	1.0	0.4	0.5	0.1
18.		1.1	0.9	0.3	0.1	0.3
	Average	1.3	0.9	0.4	0.3	0.2
23.	Idle-Acceleration	1.1	0.8	0.4	0.3	0.1
28.		1.3	1.0	0.5	0.3	0.3
29.		1.5	1.0	0.5	0.4	0.3
31.		1.6	1.0	0.6	0.4	0.3
	Average	1.4	1.0	0.5	0.4	0.3
24.	Acceleration	2.1	1.0	0.8	0.3	0.5
26.		2.2	0.9	0.8	0.4	0.6
30.		2.1	1.0	0.6	0.3	0.6
33.		1.9	0.9	0.8	0.1	0.4
	Average	2.1	1.0	0.8	0.3	0.5
22.	Deceleration	0.9	0.9	0.3	0.4	0.1
25.		0.9	0.9	0.3	0.1	0.1
27.		1.0	0.6	0.3	0.3	0.1
32.		1.1	0.8	0.3	0.1	0.1
	Average	1.0	0.8	0.3	0.2	0.1
	Cold Start	0.8	0.5	0.1	0	0

TABLE F-4. VEHICLE ODOR EVALUATION SUMMARY

Vehicle: Mercedes 300D with A-IF, A-IR and TAV$_8$ Trap System
Date: August 6, 1976

Run No.	Operating Condition	"D" Composite	"B" Burnt	"O" Oily	"A" Aromatic	"P" Pungent
10.	Inter. Speed	2.6	1.0	0.6	0.3	0.7
13.	No Load	1.1	1.0	0.1	0.1	0
14.		1.4	0.9	0.4	0.3	0
	Average	1.7	1.0	0.4	0.2	0.2
1.	Inter. Speed	1.0	1.0	0.1	0	0
7.	Mid Load	0.9	0.9	0	0.1	0
20.		0.9	0.7	0.1	0.1	0
	Average	0.9	0.9	0.1	0.1	0
5.	Inter. Speed	0.9	0.8	0	0.1	0
8.	High Load	0.7	0.7	0	0	0
19.		1.0	0.5	0.1	0.1	0.4
	Average	0.9	0.7	0	0.1	0.1
4.	High Speed	0.7	0.7	0	0	0
16.	No Load	1.3	1.0	0.3	0.1	0
21.		1.0	0.8	0.2	0.1	0
	Average	1.0	0.8	0.2	0.1	0
6.	High Speed	1.3	1.0	0.3	0.1	0
12.	Mid Load	2.1	1.1	0.9	0	0.3
18.		0.8	0.4	0.1	0.1	0.3
	Average	1.4	0.8	0.4	0.1	0.2
2.	High Speed	2.4	1.0	0.7	0.3	0.9
11.	High Load	2.6	1.0	0.7	0.6	0.4
15.		2.6	1.0	0.9	0.3	0.6
		2.5	1.0	0.8	0.4	0.6
3.	Idle	1.5	0.9	0.4	0.1	0.1
9.		1.1	0.9	0.3	0.3	0
17.		0.9	0.8	0.1	0.1	0
	Average	1.2	0.9	0.3	0.2	0
23.	Idle-Acceleration	1.3	0.9	0.1	0.3	0.1
26.		1.0	1.0	0.1	0.1	0
28.		1.6	0.7	0.1	0.7	0.1
31.		1.1	0.7	0.1	0.4	0
	Average	1.3	0.8	0.1	0.4	0.1
22.	Acceleration	2.3	1.0	0.3	0.1	1.0
25.		2.0	1.0	0.1	0.4	0.9
29.		2.1	1.0	0.4	0.7	0.3
32.		1.9	1.0	0.3	0.3	0.4
	Average	2.1	1.0	0.3	0.4	0.7
24.	Deceleration	0.9	0.8	0.1	0	0
27.		0.8	0.4	0.1	0.2	0
30.		0.9	0.6	0.2	0.1	0
33.		1.0	0.6	0.1	0.3	0
	Average	0.9	0.6	0.1	0.2	0
	Cold Start	0.7	0.7	0.1	0	0

TABLE F-5. VEHICLE ODOR EVALUATION SUMMARY

Vehicle: Mercedes 300D with Standard Exhaust System and Backpressure
Date: August 9, 1976

Run No.	Operating Condition	"D" Composite	"B" Burnt	"O" Oily	"A" Aromatic	"P" Pungent
6.	Inter. Speed	1.8	1.0	0.9	0.3	0.3
11.	No Load	2.9	1.0	0.9	0.6	0.4
15.		2.1	1.0	1.0	0.3	0.3
	Average	2.3	1.0	0.9	0.4	0.3
2.	Inter. Speed	2.0	1.0	0.9	0.3	0.1
8.	Mid Load	2.3	1.0	1.0	0.3	0.3
18.		1.7	1.0	0.7	0.3	0.3
	Average	2.0	1.0	0.9	0.3	0.2
1.	Inter. Speed	1.7	0.9	0.9	0.3	0.1
9.	High Load	2.2	1.0	1.0	0.4	0.3
19.		2.1	1.0	1.0	0.3	0.3
	Average	2.0	1.0	1.0	0.3	0.2
5.	High Speed	2.0	1.0	1.0	0.3	0.1
12.	No Load	2.7	1.0	1.0	0.4	0.7
17.		2.3	1.0	1.0	0.3	0.4
	Average	2.3	1.0	1.0	0.3	0.4
7.	High Speed	3.0	1.0	1.0	0.6	0.6
14.	Mid Load	3.0	1.0	1.0	0.6	0.6
20.		2.7	1.0	1.0	0.4	0.6
	Average	2.9	1.0	1.0	0.5	0.6
3.	High Speed	3.0	1.3	1.0	0.1	0.6
13.	High Load	3.4	1.0	1.0	0.6	0.7
21.		2.9	1.0	1.0	0.6	0.7
	Average	3.1	1.1	1.0	0.4	0.7
4.	Idle	1.5	0.9	0.6	0	0.1
10.		2.7	1.0	0.9	0.7	0.6
16.		2.4	1.0	1.0	0.4	0.3
	Average	2.2	1.0	0.8	0.4	0.3
24.	Idle-Acceleration	2.7	1.0	1.0	0.4	0.6
26.		2.3	1.0	1.0	0.4	0.1
27.		2.6	1.0	1.0	0.3	0.4
32.		2.4	1.0	1.0	0.6	0.4
	Average	2.5	1.0	1.0	0.4	0.4
22.	Acceleration	2.3	1.0	1.0	0.3	0.3
25.		2.3	1.0	1.0	0.3	0.1
29.		2.1	1.0	1.0	0.3	0.3
31.		1.9	1.0	1.0	0.3	0.3
	Average	2.2	1.0	1.0	0.3	0.3
23.	Deceleration	2.6	1.0	1.0	0.4	0.3
28.		3.1	1.0	1.0	0.4	1.0
30.		2.4	1.0	1.0	0.3	0.6
33.		2.7	1.0	1.0	0.3	0.7
	Average	2.7	1.0	1.0	0.4	0.7
	Cold Start	3.4	1.0	1.0	0.7	0.9

TABLE F-6. VEHICLE ODOR EVALUATION SUMMARY

Vehicle: Mercedes 300D with Standard Exhaust System and
Same Backpressure as Trap System at 50 mph
Date: August 11, 1976

Run No.	Operating Condition	"D" Composite	"B" Burnt	"O" Oily	"A" Aromatic	"P" Pungent
10.	Inter. Speed	2.5	1.0	0.8	0.5	0.6
13.	No Load	1.6	1.0	0.4	0.6	0.3
14.		1.1	0.9	0.3	0.3	0.3
	Average	1.7	1.0	0.5	0.5	0.4
1.	Inter. Speed	1.4	0.9	0.5	0.5	0.1
7.	Mid Load	1.5	0.8	0.6	0.3	0.1
20.		1.2	0.9	0.4	0.3	0.1
	Average	1.4	0.9	0.5	0.4	0.1
5.	Inter. Speed	1.0	0.8	0.2	0.1	0.1
8.	High Load	1.1	0.8	0.4	0	0.1
19.		1.3	1.0	0.4	0.1	0.4
	Average	1.1	0.9	0.3	0.1	0.2
4.	High Speed	1.6	0.9	0.1	0.5	0.2
16.	No Load	1.3	0.9	0.4	0.3	0.3
21.		2.1	1.0	0.7	0.4	0.3
	Average	1.7	0.9	0.4	0.4	0.3
6.	High Speed	2.0	1.0	0.8	0.5	0.3
12.	Mid Load	2.4	1.0	0.6	0.6	0.4
18.		2.1	1.0	0.7	0.4	0.5
	Average	2.2	1.0	0.7	0.5	0.4
2.	High Speed	2.5	1.0	1.0	0.5	0.4
11.	High Load	2.0	1.0	0.6	0.6	0.1
15.		1.9	1.0	0.6	0.1	0.1
	Average	2.1	1.0	0.7	0.4	0.2
3.	Idle	1.7	1.0	0.4	0.6	0.1
9.		1.8	1.0	0.4	0.4	0.3
17.		1.5	1.0	0.4	0.4	0.1
	Average	1.7	1.0	0.4	0.5	0.2
23.	Idle-Acceleration	2.0	1.0	0.5	0.5	0.5
26.		1.8	1.0	0.5	0.4	0.3
28.		1.6	1.0	0.6	0.4	0.3
31.		2.3	1.0	0.9	0.3	0.4
	Average	1.9	1.0	0.6	0.4	0.4
22.	Acceleration	1.9	1.0	0.5	0.8	0.1
25.		1.8	1.0	0.6	0.4	0.4
29.		2.6	1.0	1.0	0.3	0.6
32.		3.0	1.0	1.0	0.3	0.8
	Average	2.3	1.0	0.8	0.5	0.5
24.	Deceleration	1.9	1.0	0.8	0.4	0.5
27.		2.3	1.0	0.6	0.5	0.4
30.		2.3	1.0	0.9	0.3	0.4
33.		2.2	1.0	0.9	0.1	0.3
	Average	2.2	1.0	0.8	0.3	0.4
	Cold Start	2.9	1.0	1.0	0.4	0.8

TABLE F-7. COMPARISON OF GASEOUS EMISSIONS MEASUREMENTS
(Mercedes 300D with Particulate Trap System)

Operating Condition	Date	HC, ppmC	CO, ppm	NDIR NO, ppm	C.L. NO, ppm	C.L. NO$_x$, ppm	CO$_2$, %	Air Flow, kg/min	DOAS Results LCA, µg/l	DOAS Results LCO, µg/l	DOAS Results TIA
Inter. Speed No Load	8/2/76	27	188	99	93	98	2.7	1.78	-	-	-
	8/4/76	26	283	107	83	84	2.5	2.00	-	-	-
	8/6/76	25	235	106	97	99	2.7	2.63	0.7	1.0	1.0
	Average	26	235	104	91	94	2.6	2.14	0.7	1.0	1.0
Inter. Speed Mid Load	8/2/76	29	155	251	210	215	4.5	2.45	-	-	-
	8/4/76	25	207	233	206	210	4.4	2.65	-	-	-
	8/6/76	19	240	270	201	203	4.8	2.65	1.0	1.1	1.0
	Average	24	201	251	206	209	4.6	2.58	1.0	1.1	1.0
Inter. Speed High Load	8/2/76	24	164	352	282	285	5.8	2.56	-	-	-
	8/4/76	24	183	337	288	292	5.3	2.64	-	-	-
	8/6/76	17	178	339	285	289	6.2	2.68	1.0	1.1	1.1
	Average	22	175	343	285	289	5.8	2.63	1.0	1.1	1.1
High Speed No Load	8/2/76	18	230	119	113	118	3.4	3.65	-	-	-
	8/4/76	31	316	151	122	124	3.3	4.19	-	-	-
	8/6/76	29	330	147	124	130	3.6	4.16	1.2	1.3	1.1
	Average	26	292	139	120	124	3.4	4.00	1.2	1.3	1.1
High Speed Mid Load	8/2/76	29	193	437	373	378	7.7	4.00	-	-	-
	8/4/76	29	202	436	367	370	7.0	4.15	-	-	-
	8/6/76	14	221	432	353	360	7.3	4.16	2.1	1.9	1.3
	Average	24	205	435	364	369	7.3	4.10	2.1	1.9	1.3
High Speed High Load	8/2/76	48	240	524	442	445	10.6	4.03	-	-	-
	8/4/76	56	269	532	458	462	10.3	4.11	-	-	-
	8/6/76	37	278	536	447	453	10.7	4.09	4.1	2.7	1.4
	Average	47	262	531	449	453	10.5	4.08	4.1	2.7	1.4
Idle	8/2/76	55	240	140	118	128	2.8	0.77	-	-	-
	8/4/76	37	254	124	102	107	2.4	0.82	-	-	-
	8/6/76	38	273	137	115	125	2.8	0.80	2.2	1.8	1.2
	Average	43	256	134	112	120	2.7	0.80	2.2	1.8	1.2

TABLE F-8. GASEOUS EMISSIONS MEASUREMENTS

Vehicle: Mercedes 300D with A-IF, A-IR and TAV$_s$ Trap System
Date: August 2, 1976

Run No.	Operating Condition	HC, ppmC	CO, ppm	NDIR NO, ppm	C. L. NO, ppm	C. L. NO$_x$, ppm	CO$_2$, %	Air Flow, kg/min
6.	Inter. Speed	32	155	88	90	95	2.5	1.70
11.	No Load	28	240	99	85	90	2.8	1.78
15.		20	169	111	105	110	2.7	1.86
	Average	27	188	99	93	98	2.7	1.78
2.	Inter. Speed	32	169	251	200	205	4.4	2.45
8.	Mid Load	40	141	251	215	220	4.4	2.44
18.		16	155	251	215	220	4.8	2.45
	Average	29	155	251	210	215	4.5	2.45
1.	Inter. Speed	28	197	386	290	295	6.0	2.51
9.	High Load	32	141	323	260	260	5.2	2.55
19.		12	155	348	295	300	6.2	2.62
	Average	24	164	352	282	285	5.8	2.56
5.	High Speed	32	197	88	95	100	2.8	3.22
12.	No Load	40	268	134	120	130	3.7	3.89
17.		12	226	134	125	125	3.6	3.83
	Average	18	230	119	113	118	3.4	3.65
7.	High Speed	40	169	437	340	350	6.9	3.97
14.	Mid Load	32	240	476	420	425	8.7	3.98
20.		16	169	398	360	360	7.6	4.04
	Average	29	193	437	373	378	7.7	4.00
3.	High Speed	64	226	555	430	430	9.7	3.98
13.	High Load	56	268	502	445	445	11.1	4.09
21.		24	226	515	450	460	10.9	4.02
	Average	48	240	524	442	445	10.6	4.03
4.	Idle	60	283	156	130	140	2.9	0.75
10.		72	212	134	115	120	2.5	0.78
16.		32	226	130	110	125	2.9	0.77
	Average	55	240	140	118	128	2.8	0.77

TABLE F-9. GASEOUS EMISSIONS MEASUREMENTS

Vehicle: Mercedes 300D with A-IF, A-IR, and TAV$_8$ Trap System
Date: August 4, 1976

				NDIR	C. L.				DOAS Results		
Run No.	Operating Condition	HC, ppmC	CO, ppm	NO, ppm	NO, ppm	NO$_x$, ppm	CO$_2$, %	Air Flow, kg/min	LCA, µg/l	LCO, µg/l	TIA
7.	Inter. Speed	28	283	107	78	80	2.6	1.98	0.5	1.7	1.2
11.	No Load	28	297	107	80	83	2.3	1.98	0.3	1.7	1.2
16.		22	268	107	90	90	2.7	2.05	-	-	-
	Average	26	283	107	83	84	2.5	2.00	0.4	1.7	1.2
4.	Inter. Speed	22	226	218	202	205	4.6	2.69	0.6	1.9	1.3
14.	Mid Load	28	226	239	200	205	3.9	2.65	0.6	1.7	1.2
20.		24	169	243	216	220	4.6	2.61	0.5	3.1	1.5
	Average	25	207	233	206	210	4.4	2.65	0.6	2.2	1.3
3.	Inter. Speed	20	169	309	270	275	5.7	2.60	0.7	1.6	1.2
13.	High Load	38	212	360	300	305	5.2	2.66	0.6	2.4	1.4
21.		14	169	343	295	295	5.1	2.67	0.5	2.2	1.4
	Average	24	183	337	288	292	5.3	2.64	0.6	2.1	1.3
5.	High Speed	28	339	138	117	116	3.3	4.25	0.9	1.8	1.3
10.	No Load	36	325	166	130	132	3.4	4.16	0.9	2.5	1.4
17.		30	283	150	120	123	3.3	4.17	1.0	3.9	1.6
	Average	31	316	151	122	124	3.3	4.19	0.9	3.1	1.4
2.	High Speed	24	212	465	350	355	7.0	4.07	4.6	4.0	1.6
8.	Mid Load	40	197	447	370	375	6.9	4.19	5.7	3.6	1.6
15.		24	197	395	380	380	7.1	4.18	3.4	3.2	1.5
	Average	29	202	436	367	370	7.0	4.15	4.6	3.6	1.6
1.	High Speed	56	226	514	440	445	10.6	4.12	8.2	4.6	1.7
9.	High Load	56	297	532	460	460	9.8	4.09	7.0	4.6	1.7
19.		56	283	551	475	480	10.6	4.11	6.9	3.9	1.6
		56	269	532	458	462	10.3	4.11	7.4	4.4	1.7
6.	Idle	34	268	126	105	110	2.5	0.83	0.4	2.0	1.3
12.		40	283	115	85	90	2.1	0.83	0.4	1.6	1.2
18.		36	212	130	115	120	2.7	0.81	0.2	1.8	1.3
	Average	37	254	124	102	107	2.4	0.82	0.3	1.8	1.3

TABLE F-10. GASEOUS EMISSIONS MEASUREMENTS

Vehicle: Mercedes 300D with A-IF, A-IR, TAV$_6$ Trap System
Date: August 6, 1976

Run No.	Operating Condition	HC, ppmC	CO, ppm	NDIR NO, ppm	C. L. NO, ppm	C. L. NO$_x$, ppm	CO$_2$, %	Air Flow, kg/min	DOAS Results LCA, µg/l	DOAS Results LCO, µg/l	DOAS Results TIA
10.	Inter. Speed No Load	42	197	95	130	130	2.7	2.64			
13.		16	254	111	80	85	2.7	2.63			
14.		18	254	111	80	82	2.7	2.62			
	Average	25	235	106	97	99	2.7	2.63	0.7	1.0	1.0
1.	Inter. Speed Mid Load	12	311	284	209	210	4.6	2.63			
7.		24	169	301	198	200	4.6	2.62			
20.		22	240	226	195	200	5.1	2.69			
	Average	19	240	270	201	203	4.8	2.65	1.0	1.1	1.0
5.	Inter. Speed High Load	16	169	360	285	290	6.0	2.70			
8.		20	183	330	290	295	5.9	2.72			
19.		14	183	326	280	282	6.6	2.61			
	Average	17	178	339	285	289	6.2	2.68	1.0	1.1	1.1
4.	High Speed No Load	28	297	162	123	130	3.4	4.26			
16.		28	254	138	120	130	3.5	4.14			
21.		32	439	142	130	130	3.9	4.08			
	Average	29	330	147	124	130	3.6	4.16	1.2	1.3	1.1
6.	High Speed Mid Load	18	197	447	340	350	6.9	4.20			
12.		12	240	438	365	370	7.4	4.13			
18.		12	226	412	353	360	7.5	4.14			
	Average	14	221	432	353	360	7.3	4.16	2.1	1.9	1.3
2.	High Speed High Load	42	311	551	435	445	10.4	4.09			
11.		36	283	551	450	455	10.9	4.09			
15.		32	240	505	455	459	10.9	4.09			
	Average	37	278	536	447	453	10.7	4.09	4.1	2.7	1.4
3.	Idle	36	311	158	125	135	2.9	0.79			
9.		46	240	130	110	125	2.6	0.83			
17.		32	268	122	110	115	2.8	0.78			
	Average	38	273	137	115	125	2.8	0.80	2.2	1.8	1.2

* One bubbler taken for each 3 runs of the same condition.

TABLE F-11. GASEOUS EMISSIONS MEASUREMENTS

Vehicle: Mercedes 300D with Standard Exhaust System and Backpressure
Date: August 9, 1976

				NDIR	C.L.				DOAS Results		
Run No.	Operating Condition	HC, ppmC	CO, ppm	NO, ppm	NO, ppm	NO_x, ppm	CO_2, %	Air Flow, kg/min	LCA, µg/l	LCO, µg/l	TIA
6.	Inter. Speed	32	283	95	60	75	2.6	2.60	3.4	3.4	1.5
11.	No Load	42	169	72	60	75	2.6	2.61	4.5	3.8	1.6
15.		32	169	91	75	90	2.2	2.55	3.3	2.4	1.4
	Average	35	207	86	65	80	2.4	2.59	3.7	3.2	1.5
2.	Inter. Speed	34	183	230	160	175	4.3	2.59	4.6	3.3	1.5
8.	Mid Load	38	226	226	170	180	2.0	2.62	4.0	3.6	1.6
18.		36	141	226	185	198	4.6	2.56	3.5	2.4	1.4
	Average	36	183	227	172	184	3.6	2.59	4.0	3.1	1.5
1.	Inter. Speed	28	169	343	245	260	5.7	2.63	4.8	4.2	1.6
9.	High Load	10	155	326	245	253	5.5	2.66	4.1	3.1	1.5
19.		28	141	318	250	260	5.9	2.63	4.2	2.9	1.5
	Average	22	155	329	247	258	5.7	2.64	4.4	3.4	1.5
5.	High Speed	44	397	122	85	95	3.1	4.07	5.0	3.7	1.6
12.	No Load	28	283	115	90	98	2.7	4.12	6.3	3.6	1.6
17.		44	268	122	95	110	3.2	4.06	4.7	2.4	1.4
	Average	39	316	120	90	101	3.0	4.08	5.3	3.2	1.5
7.	High Speed	8	226	395	305	310	6.5	4.01	3.9	3.6	1.6
14.	Mid Load	14	169	369	335	340	4.9	4.00	5.1	4.3	1.6
20.		12	155	416	328	330	7.4	3.96	-	-	-
	Average	11	183	393	323	327	6.3	3.99	4.5	4.0	1.6
3.	High Speed	14	197	565	430	435	9.4	4.07	4.1	4.0	1.6
13.	High Load	16	155	510	455	455	7.3	4.06	5.9	4.3	1.6
21.		8	155	565	465	465	10.9	3.92	-	-	-
	Average	13	169	547	450	452	9.2	4.02	5.0	4.2	1.6
4.	Idle	60	226	130	105	115	2.7	0.81	4.0	3.1	1.5
10.		74	169	103	80	95	2.4	0.81	5.1	3.9	1.6
16.		84	169	103	85	105	2.5	0.81	4.5	2.8	1.5
	Average	71	188	112	90	105	2.5	0.81	4.5	3.3	1.5

TABLE F-12. GASEOUS EMISSIONS MEASUREMENTS

Vehicle: Mercedes 300D with Standard Exhaust System and Same Backpressure as Trap System at 50 mph
Date: August 11, 1976

				NDIR	C. L.				DOAS Results		
Run No.	Operating Condition	HC, ppmC	CO, ppm	NO, ppm	NO, ppm	NO_x, ppm	CO_2, %	Air Flow, kg/min	LCA, µg/l	LCO, µg/l	TIA
10.	Inter. Speed	50	183	64	63	80	2.8	2.69	4.5	2.4	1.4
13.	No Load	30	212	84	70	85	3.0	2.63	3.2	2.2	1.4
14.		36	212	84	70	85	2.8	2.62	3.9	2.4	1.4
	Average	39	202	77	68	83	2.9	2.65	3.9	2.3	1.4
1.	Inter Speed.	26	141	239	172	185	4.4	2.63	4.5	3.0	1.5
7.	Mid Load	34	197	210	160	170	4.4	2.62	3.6	2.3	1.4
20.		40	169	202	170	180	4.6	2.63	3.4	2.0	1.3
	Average	33	169	217	167	178	4.5	2.63	3.8	2.4	1.4
5.	Inter. Speed	10	212	330	250	260	5.9	2.71	3.2	2.2	1.4
8.	High Load	30	226	313	235	250	5.7	2.72	2.6	2.2	1.3
19.		24	141	352	275	285	6.2	2.67	2.5	1.8	1.3
	Average	21	193	332	253	265	5.9	2.70	2.8	2.1	1.3
4.	High Speed	32	325	186	90	100	3.3	4.26	4.1	2.6	1.4
16.	No Load	38	268	154	120	125	3.6	4.06	3.7	2.3	1.4
21.		32	254	126	105	130	3.6	4.15	3.3	1.9	1.3
	Average	34	282	155	105	118	3.5	4.16	3.7	2.3	1.4
6.	High Speed	8	197	386	315	320	6.9	4.22	2.6	2.1	1.3
12.	Mid Load	12	169	425	335	340	6.9	4.14	2.6	2.1	1.3
18.		8	169	416	350	350	7.4	4.13	2.6	2.3	1.4
	Average	9	178	409	333	337	7.1	4.16	2.6	2.2	1.3
2.	High Speed	12	197	565	445	450	10.3	4.17	4.0	3.3	1.5
11.	High Load	28	141	519	435	440	10.4	4.14	5.7	3.4	1.5
15.		8	141	611	453	460	10.4	4.02	3.1	2.3	1.3
	Average	16	160	565	444	450	10.4	4.11	4.3	3.0	1.4
3.	Idle	32	212	174	125	135	2.8	0.83	1.7	1.0	1.0
9.		68	183	162	115	130	2.8	0.82	3.6	2.0	1.3
17.		50	197	138	110	125	2.6	0.82	3.1	1.8	1.3
	Average	50	197	158	117	130	2.7	0.82	2.8	1.6	1.2

APPENDIX G

NOISE DATA

TABLE G-1. MERCEDES 300D FACTORY EQUIPPED DIESEL CAR NOISE DATA - dBA SCALE

Date: July 28, 1975 Wind: 6.0 km/hr SSE

Acceleration Test (2nd Gear)

Ambient: Before Test 42-44 After Test 42-44

	Pass			Arithmetic Average(2)
	1st	2nd	3rd	
Exterior at 15.24m(1)				
Right to Left	70	71.5	71.5	71.5
Left to Right	71.5	71.5	72	71.8
Interior				
Fresh Air Blr Off	76	75	77	76.5
Fresh Air Blr On	79	78.5	79	79

Constant Speed 48.3 km/hr Driveby

Ambient: Before Test 42-44 After Test 42.44

	Pass			Arithmetic Average(2)
	1st	2nd	3rd	
Exterior at 15.24 m				
Right to Left	59.5	59.5	59.5	59.5
Left to Right	59	58.5	58.5	58.8
Interior				
Fresh Air Blr Off	64	63.5	63.5	63.8
Frest Air Blr On	75.5	76	75	75.8

Engine Idle, Vehicle at Rest

Ambient: Before Test 42-44 After Test 42-44

	Test 1 - Direction A				Test 2 - Direction B				Max Reading
Interior	54 (68.5 Blr On)				54.5 (68.5 Blr On)				68.5
	Front	Rear	Left	Right	Front	Rear	Left	Right	
Exterior	67	58	66.5	64.5	66.5	59	66.5	64.5	67

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(1) According to SAE J-986a

(2) Average of the two highest readings that are within 2 dB of each other.

TABLE G-2. MERCEDES 300D DIESEL CAR NOISE DATA - dBA SCALE
(with A-IF, A-IR, and TAV$_S$ traps)

Date: August 27, 1976 Wind: 7.0 km/hr SSE

Acceleration Test (2nd Gear)

Ambient: Before Test 40-45 After Test 40-45

	Pass			Arithmetic Average[2]
	1st	2nd	3rd	
Exterior at 15.24m[1]				
Right to Left	83	85	82	84
Left to Right	76	78	78	78
Interior				
Fresh Air Blr Off	77	77	75	77
Fresh Air Blr On	78	79	79	79

Constant Speed 48.3 km/hr Driveby

Ambient: Before Test 40-45 After Test 40-45

	Pass			Arithmetic Average[2]
	1st	2nd	3rd	
Exterior at 7.62m				
Right to Left	60.5	60	61	60.8
Left to Right	61	60	59.5	60.5
Interior				
Fresh Air Blr Off	69	68	70	69.5
Fresh Air Blr On	74	74	73	74

Engine Idle, Vehicle at Rest

Ambient: Before Test 40-45 After Test 40-45

	Test 1 - Direction A				Test 2 - Direction B				Max Reading
Interior	58 (68.5 Blr On)				58 (68.5 Blr On)				68.5
	Front	Rear	Left	Right	Front	Rear	Left	Right	
Exterior	69.5	61.5	66.5	65.0	69	61.5	65.5	64	69.5
Radiator Aux.Blr On	73	61.5	66.5	65.0	74	61.5	65.5	64	74

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(1) According to SAE J-986a.

(2) Average of the two highest readings that are within 2 dB of each other.

APPENDIX H

EXHAUST SYSTEM BACKPRESSURES MEASURED DURING MVMA MILEAGE ACCUMULATION

TABLE H-1. EXHAUST SYSTEM BACKPRESSURE DURING MVMA DURABILITY TEST OF PARTICULATE TRAP SYSTEM - MERCEDES 300D
88.5 km (55 mph) During Lap 10

Distance km	Test Conf	Backpressure Readings, mm Hg Man	Front Muf/Trap in	Front Muf/Trap out	Rear Muf/Trap in	Rear Muf/Trap out(1)	Front ΔP	Rear ΔP
0	1	199	211	181	172	99	28	65
170	1	178	187	150	140	84	30	64
305	1	178	168	140	131	75	34	64
470	1	187	187	150	150	75	30	67
611	1	178	187	150	140	75	34	71
772	1	252	271	234	215	131	34	93
922	1	252	262	215	206	121	34	90
1084	1	262	[illegible]	234	224	131	34	90
1234	1	280	[illegible]	252	243	140	37	97
1272	2	174	174	140	129	18	34	110
	2(2)	142	138	108	97	0	32	37
	2(3)	144	144	112	90	13	32	90
1517	3	215	215	178	178	93	34	84
1667	3	206	206	178	178	93	34	90
1828	3	215	206	178	168	84	34	84
1976	3	224	224	196	187	84	34	90
2138	3	206	228	187	150	75	34	93
2286	3	206	206	187	150	75	34	93
2388	3	242	228	205	178	84	34	101
2590	3	224	224	196	187	78	34	101
2735	3	243	243	205	187	84	34	101
2886	3	243	243	187	168	84	34	101
3033	3	234	234	187	178	84	37	104
3191	3	224	234	206	187	84	37	104
3353	1	280	262	234	224	121	34	97
3490	1	262	262	234	224	127	37	97
3651	1	284	284	252	243	140	37	105
3790	1	284	280	262	262	140	41	108
3942	1	271	280	243	234	121	41	103
4092	1	271	271	243	224	131	39	103
4023 km (2500 mile) particulate tests								
4312	1	275	275	243	224	131	34	90
4462	1	280	280	243	234	131	38	101
4616	1	284	284	243	243	140	41	112
4756	1	284	284	252	252	140	41	112
4906	1	280	280	243	243	140	38	101
5054	1	280	280	243	243	140	38	99
5223	1	310	299	271	262	140	41	112
5279	2	206	206	159	140	9	48	112
5372	2	181	178	131	121	9	48	112
5524	1	280	280	243	234	131	41	93
5681	1	280	280	243	234	131	41	93
5839	1	284	280	252	252	140	45	108
5992	1	297	290	271	262	140	48	103

TABLE H-1. (Cont'd) EXHAUST SYSTEM BACKPRESSURE DURING MVMA DURABILITY TEST OF PARTICULATE TRAP SYSTEM - MERCEDES 300D

4023 km (2500 mile) particulate test (cont'd)

Distance km	Test Conf	Backpressure Readings, mm Hg Man	Front Muf/Trap in	Front Muf/Trap out	Rear Muf/Trap in	Rear Muf/Trap out(1)	Front ΔP	Rear ΔP
6141	1	280	280	243	243	131	41	97
6296	1	290	284	262	262	140	47	103
6457	1	323	299	262	252	140	49	112
6507	2	206	[illegible]	131	131	9	52	123
6743	2	178	158	112	112	9	45	108
6901	1	284	261	224	215	140	41	93
7054	1	280	271	243	224	131	45	103
7200	1	280	[illegible]	224	224	127	41	93
7355	1	290	[illegible]	234	[illegible]	112	39	95
7504	1	310	280	262	243	140	43	106
7656	1	280	280	247	243	131	45	103
7805	1	280	280	262	243	131	45	99
7964	1	310	280	262	243	112	47	101
8116	1	290	280	243	234	112	43	99
8270	1	280	280	243	243	121	47	101
8418	1	290	290	252	243	131	49	112
			8045 km (5000 mile) emission & particulate tests					
8991	1	295	290	262	278	136	43	99
9140	1	310	299	280	271	131	47	103
9300	1	299	299	243	243	149	47	112
9445	1	299	299	271	262	149	47	112
9594	1	316	299	280	271	131	47	108
9742	1	299	290	275	271	127	45	108
9895	1	340	323	271	262	140	49	116
10048	1	310	290	269	262	140	47	112
10199	1	310	290	278	271	140	47	114
10349	1	299	290	262	258	133	50	116
10508	1	323	299	271	262	140	49	116
10652	1	323	303	280	262	140	49	120
10801	2	243	239	168	140	19	75	131
11111	1	349	321	252	234	112	52	121
11255	1	310	293	271	252	131	48	116
11404	1	310	290	280	271	127	50	116
11554	1	310	290	267	262	122	47	116
11707	1	323	299	262	243	121	52	118
11858	1	323	295	271	262	140	52	118
			12068 km (7500 mile) particulate tests					
12099	5	159	140	121	108	112	15	0
12244	5	150	150	140	112	112	15	0
12397	5	159	138	112	108	121	19	0
12545	5	150	151	133	131	116	15	0
12703	5	140	140	131	127	131	15	0

TABLE H-1. (Cont'd) EXHAUST SYSTEM BACKPRESSURE DURING MVMA DURABILITY TEST OF PARTICULATE TRAP SYSTEM - MERCEDES 300D

12068 km (7500 mile) particulate test (cont'd)

		Backpressure Readings, mm Hg						
Distance km	Test Conf	Man	Front Muf/Trap in	Front Muf/Trap out	Rear Muf/Trap in	Rear Muf/Trap out(1)	Front ΔP	Rear ΔP
12845	5	146	140	127	116	112	15	0
13006	5	140	131	112	112	107	15	0
13139	5	150	131	108	112	116	15	0
13292	6	47	37	9	0	0	13	0
13442	5	127	112	93	92	93	17	0
13601	5	103	93	84	77	78	11	0
13744	5	103	93	82	75	75	11	0
13895	5(4)	58	65	60	47	41	9	0
14045	5(4)	65	56	50	47	47	9	0
14196	5(4)	41	37	28	28	28	7	0
14328	5	168	159	155	142	140	4	0
14479	4	56	19	17	---	---	6	0
14642	4	127	112	105	88	86	7	0
14787	4	131	121	103	90	84	6	0
14936	4	131	116	108	97	95	7	0
15086	4	103	99	97	93	92	6	0
15247	4	121	103	103	84	84	7	0
15390	4	131	114	105	93	90	6	0
15539	4	121	120	112	93	93	6	0
15689	4	118	112	112	93	92	6	0
15850	4	127	112	112	95	97	6	0
16006	4	153	140	112	92	86	6	0
End of Test	4(5)	80	68	68	59	59	4	0
	6(5)	23	11	9	0	0	4	0

Test Configuration

1. A-IF, A-IR, TAV_S
2. A-IF, A-IR
3. A-IF, A-IR, Swirl
4. Factory, Swirl
5. Factory, TAV_S
6. Factory

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(1) Rear muf/trap outlet same as TAV_S/Swirl separator In.

(2) Rear outlet cone removed from A-IR to check system pressures

(3) Rear outlet cone replaced after improving flow transition by grinding welds.

(4) Front muffler damaged, readings in error

(5) Measured by two technicians